Hyperventilation

The term hyperventilation describes excessive ventilation of the lungs, beyond what is required to achieve normal arterial blood gases.

Where hyperventilation occurs chronically or in recurrent episodes and is associated with somatic (respiratory, neurological, intestinal) or psychological (anxiety) symptoms, it is known as hyperventilation syndrome.\(^1\)

About 5-10% of general medical outpatients are thought to have this syndrome and, because of the range of somatic symptoms, the risk of misdiagnosis is high.

Pathogenesis

Hyperventilation has little effect on arterial $pO_2$ and almost no effect on oxygen saturation which is nearly 100% under normal circumstances. Its main effect is to lower $pCO_2$ and produce a respiratory alkalosis. A secondary hypocalcaemia also occurs as calcium dissociation is shifted towards the unionised, bound form.

There are many factors that influence the respiratory drive, including the elasticity of the lungs and the resistance in the airways but the most important factors are arterial pH, $pCO_2$ and $pO_2$.

Of these, $pCO_2$ is most important, although some people with chronic obstructive pulmonary disease (COPD) can depend on the hypoxic drive.

Epidemiology

- It is quite common but precise prevalence is unknown. A postal survey indicated that 8% of adults without asthma have functional breathing problems (of which symptomatic hyperventilation is the most common).\(^2\)
- Hyperventilation syndrome is more common in people with asthma and also more common in females.\(^3\)
- It is more common in asthmatic patients, occurring in 29% in one survey.\(^4\)

Aetiology

The most common reason for increasing respiratory rate and depth is exercise, the extent depending upon the level of exercise. However, as this is a normal physiological response, it is inappropriate to call it hyperventilation.

Other causes include:

- Metabolic acidosis, which will cause compensatory hyperventilation. This may occur with diabetic ketoacidosis or with acute kidney injury. Carbon dioxide is a very weak acid but the volume exchanged in a day makes it the most important contributor to acid base balance.
- Problems of respiratory exchange may exist, including V/Q imbalance due to, for example, pulmonary embolism or poor gas exchange with pulmonary oedema.
- Hypoxia, which can be the result of altitude, especially when ascent has been too rapid and acclimatisation has not occurred. Hyperventilation can cause mountain sickness with cerebral oedema. Rapid descent is imperative as the condition can be fatal.
- Fever, toxins and drugs - these can all increase the respiratory rate, possibly by a central action on the brain.
- Aspirin overdose, which leads first to a primary hyperventilation and respiratory alkalosis by central stimulation and then to a secondary hyperventilation for the metabolic acidosis caused by the acidic nature of the drug.
Iatrogenic hyperventilation by over-ventilating patients with head injuries, which was once a common technique but has fallen from favour, as it has been shown to produce a worse outcome.[5] Hyperventilation in response to anxiety, which is common. It is more common in women and may be associated with panic disorder. Hyperventilation which may also occur as part of dysfunctional breathing in those with asthma.[4]

The remainder of this article will concentrate on hyperventilation as it may present in the community.

Presentation

Symptoms
- The complaint is usually of a paroxysmal rather than a continuous nature, although chronic hyperventilation can occur.
- The patient may complain of shortness of breath when an attack occurs.
- Pain or discomfort in the chest is common.
- Paraesthesiae usually affects both arms. The complaint is often of numbness or tingling in the fingers and sometimes toes.
- Other symptoms include:
  - Dizziness.
  - Perioral tingling.
  - Weakness.
  - Tinnitus.
  - Palpitations.
  - Feeling of choking or suffocation.
  - Wheezing.
  - Sweating.
  - Loss of consciousness (uncommon).

Signs
There are unlikely to be any signs unless the patient is seen during an acute attack when:
- The patient will look very anxious and be struggling to breathe.
- Speech is difficult and the accessory muscles of ventilation are used.
- Note the ratio of the inspiratory duration to the expiratory duration:
  - In quiet breathing, this is about 1:2.
  - In asthma, the expiratory phase is prolonged (especially if severe) and the patient may expire through pursed lips.
  - In hyperventilation, the inspiratory phase may be more energetic and the expiratory phase is not prolonged.

- Trousseau's sign (also called 'main d'accoucheur' or carpopedal spasm) is muscle spasm in the hands, with the tips of the fingers and thumb apposed and the fingers straight. It results from hypocalcaemia.
- Chvostek's sign is also due to hypocalcaemia. Flick behind the ear, just in front of the mastoid bone where the facial nerve emerges. The hypersensitive facial nerve makes the muscles of the face twitch.

Chronic hyperventilation
Chronic hyperventilation may be rather more difficult to diagnose. The patient rarely hyperventilates in a clinically apparent manner and may have been through multiple investigations already.

- There may be a persistently low arterial pCO₂ with a high renal excretion of bicarbonate so that pH is normal.
- Occasional deep, sighing breaths may be noted. These keep the pCO₂ depressed.
- They may hyperventilate more obviously when stressed and readily produce symptoms under these conditions.
Differential diagnosis

The diagnosis may be obvious from the history.

Where a patient's history is confusing, consider hyperventilation syndrome and enquire if breathlessness is:

- Occurring at rest while reading or watching TV.
- Associated with light-headedness and paraesthesiae.
- Poorly related to severity of exertion.
- Associated with fear of dying during attacks.

- **Panic attack** or agoraphobia.
- **Asthma** (mild asymptomatic asthma is not associated with clinically significant hyperventilation but is associated with a significant reduction in both arterial and end tidal pCO₂ relating to airway hyperresponsiveness). \[6\]
- Other causes of respiratory distress - eg, recurrent pulmonary emboli or pneumothorax.
- **Chest pain** (hyperventilation can precipitate angina).
- **Cervical spondylosis** and nerve compression (where sensory symptoms are unilateral).
- **Migrainous vertigo** (especially in adolescents with dizziness and headache). \[7\]

Chronic hyperventilation may mimic many serious organic disorders but features are often atypical. Patients with exercise-induced hyperventilation are more likely to have a psychiatric than a cardiac disorder. Early detection and treatment of these patients may reduce the potential morbidity associated with unnecessary invasive investigations.

Investigation

The diagnosis is essentially a clinical one but it may be necessary to perform various tests to exclude other conditions:

- Arterial blood gases in an attack may be helpful but pCO₂ can also be measured in end expiratory air. The latter test is more often used, as it is less invasive, less painful and so less likely to induce hyperventilation.
- ECG may exclude coronary heart disease or arrhythmia and D-dimer testing and CXR may be required in case of pulmonary embolism or pneumothorax. It may also reveal a prolonged QT interval due to hypocalcaemia during an acute attack.
- Pulmonary function tests and lung gas transfer help to rule out other underlying lung conditions, such as asthma or pulmonary embolism.
- Toxicology screen.
- Acute hyperventilation syndrome can be clinically misdiagnosed as epileptic seizures. Therefore an electroencephalogram (EEG) may be required. \[8\]

Management

Anxiety can cause hyperventilation, producing symptoms that are interpreted as indicating serious physical illness. This causes more hyperventilation, worse symptoms and a vicious circle. Careful explanation of the nature of the condition is needed. Patients may find it difficult to accept the aetiology. Reproducing symptoms with voluntary hyperventilation may be useful.

- Rebreathing into a paper bag can be used to help build up the pCO₂ but this should only be used where the diagnosis is certain, as it may be dangerous if there is physical disease.
- Relaxation techniques may be helpful.
- Breathing exercises are frequently used to treat dysfunctional breathing and hyperventilation syndrome. However, there is currently no strong evidence of benefit either in children or adults. \[9, 10\]
- Treating asthmatics with dysfunctional breathing, using a brief physiotherapy intervention (teaching breathing retraining exercises), improves quality of life but this is only maintained in a quarter of patients six months on. \[11\]
Pharmacological
The basis of treatment should be behavioural therapy rather than medication but there may be a place for drugs.

- Benzodiazepines can be used in the acute situation if severe. Use only occasionally, as there is the potential for sedation and dependence.
- Propranolol may be of value if asthma has been excluded.
- Tricyclic antidepressants and selective serotonin reuptake inhibitors (SSRIs) may also be of value.

Associated diseases
Treat any associated contributory conditions:

- Approximately 50% of patients with panic disorder and 60% of patients with agoraphobia hyperventilate as part of their disorder but only 25% of patients with hyperventilation syndrome also have panic disorder.
- Other psychiatric disorders - eg, obsessive-compulsive disorders; however, not all patients have demonstrable psychological pathology.

Complications

- Mortality attributable to hyperventilation syndrome is extremely rare but has been reported.[12]
- Hyperventilation syndrome can, however, have a severely adverse effect on quality of life.[13]
- There is significant psychiatric morbidity associated with the syndrome.
- Individuals are at risk of iatrogenic complications from investigation or treatment of wrong diagnosis.

Prognosis

- Prognosis is generally good but will depend on the underlying cause and comorbidity.[12]
- Management of associated disorders (such as agoraphobia) will alter the course of the hyperventilation.
- Patients treated with breathing retraining, stress reduction interventions and certain drug treatment (eg, SSRIs) appear to experience significant reductions in the frequency and the severity of exacerbations.

Further reading & references
