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Abstract

This article provides an overview of Hyperventilation Syndrome (HVS). Hyperventilation is defined as breathing in excess of metabolic requirements and in the absence of an underlying organic cause is defined as HVS. Alternative terms used in the literature are panic/anxiety attack, panic/anxiety disorder, dysfunctional breathing or breathing pattern disorder. This article provides an overview of HVS signs and symptoms beyond the familiar symptoms of tachypnoea, chest tightness, paraesthesia and anxiety. The article also discusses differential diagnoses and pre-hospital treatment of HVS, which focuses on reassuring patients and assisting them in establishing a good respiratory pattern. Patients with HVS use a significant amount of hospital and emergency service resources. Paramedics are ideally placed to diagnose and treat HVS pre-hospitally to avoid unnecessary and costly hospital admissions. Further research is needed to evaluate the pre-hospital prevalence and diagnostic accuracy for HVS, identify clear diagnostic criteria and design screening tools.

Keywords

hyperventilation syndrome

panic attack

anxiety attack

signs and symptoms

clinical diagnosis

pre-hospital

Key Points

1. Hyperventilation is defined as breathing in excess of metabolic requirements
2. HVS can also be referred to as panic/anxiety attack, panic/anxiety disorder, dysfunctional breathing or breathing pattern disorder
3. Pre-hospital treatment focuses on offering reassurance to patients and assisting them in establishing a good respiratory pattern
4. Patients with HVS use a significant amount of hospital and emergency service resources
5. Paramedics are ideally placed to diagnose and treat HVS pre-hospitally to avoid unnecessary and costly admissions to A&E departments
6. Further research is needed to evaluate the pre-hospital prevalence and diagnostic accuracy for HVS, identify clear diagnostic criteria and design screening tools

Reflective Questions

1. What are 10 signs and symptoms of HVS?
2. What are 5 differential diagnoses of HVS?
3. Reflect upon your treatment of a patient with HVS (e.g. history taking, physical examination, diagnostic tests, treatment, transport/referral).

Hyperventilation Syndrome

Hyperventilation is defined as "breathing in excess of metabolic requirements" (Gardner 2003:7), which is illustrated by an irregular and disorganised breathing pattern with an increased rate and depth of respirations, known as tachypnoea (Caroline 2016). Hyperventilation has many causes; however, this review will focus on acute episodes of primary or idiopathic hyperventilation, which means there is no underlying organic cause (Pfortmueller et al. 2015; Clarke and Townsend 2016).

Definition

The term Hyperventilation Syndrome (HVS) was first mentioned by Kerr et al. (1938) who attributed their patients' tetany to hyperventilation associated with anxiety. Since then, the term has been misused for a wide variety of medically unexplained symptoms, which has turned HVS into a "fashionable disease that is not to be taken seriously" (Hornsveld and Garssen 1997:18). Consequently, Hornsveld and Garssen (1997) suggested abandoning the term HVS despite acknowledging that patients present with HVS symptoms. It is evident from the literature that the term HVS has slowly disappeared in favour of panic/anxiety attack, panic/anxiety disorder, dysfunctional breathing or breathing pattern disorder (Thomas et al. 2001, 2005; Warburton and Jack 2006; Todd et al. 2018). However, for this review HVS was preferred as it is used in the UK national ambulance service guidelines (Brown et al. 2016).

Pathophysiology

The basic rhythm of respiration is controlled sub-consciously by the medullary respiratory centre (Aehlert 2011). This automatic activity can be over-ridden and breathing voluntarily altered or stopped momentarily in order to prevent water or irritating gases entering the lungs (Tortora and Derrickson 2011). The automatic control of respiration can also be over-ridden

by anxiety, which causes central stimulation of the medullary respiratory centre's inspiratory area, leading to an increased rate and depth of respiration (Porth and Litwack 2009).

An increased rate and depth of respiration results in faster elimination of carbon dioxide (CO_2) through exhalation whilst the body's carbon dioxide production initially stays at the same level; therefore, causing a decrease in alveolar and arterial carbon dioxide known as hypocapnia (Pizzorno et al. 2016). Hypocapnia reduces the formation of hydrogen ions (H^+) and bicarbonate ions (HCO^{3-}) in the blood causing a rise in pH levels known as respiratory alkalosis (Khurana 2012).

According to the literature, hypocapnia also reduces blood flow to the brain by 2% per 1 mmHg reduction in arterial partial pressure of carbon dioxide ($PaCO_2$) (Pizzorno et al. 2016). This is due to hypocapnia causing constriction of cerebral arteries, which increases vascular resistance and reduces cerebral blood flow (Pizzorno et al. 2016). This diminished cerebral perfusion may explain some of the neurological symptoms associated with HVS (Evans 2005).

Signs and Symptoms

Signs and symptoms of HVS are wide-ranging, vague and can vary between patients as illustrated in Table 1. The common symptoms of tetany, paraesthesia and carpopedal spasm are believed to be associated with excessive expiration of carbon dioxide during episodes of tachypnoea leading to hypocapnia and respiratory alkalosis (Porth and Litwack 2009). Experiencing these frightening symptoms exacerbates patients' anxiety which promotes further hyperventilation resulting in HVS symptoms entering a vicious cycle (Clarke and Townsend 2016). The physiological mechanisms by which many of the other symptoms occur are not entirely clear; however, Chapman et al. (2009) emphasize that HVS symptoms are genuine consequences of physiological imbalances and not figments of patients' imagination.

BODY SYSTEM	SIGNS AND SYMPTOMS
Cardiovascular	Palpitations/tachycardia, arrhythmias, chest pain, blotchy flushing
Neurological	paraesthesia to extremities or face, dizziness/unsteadiness, syncope, headache, blurred or tunnel vision, impaired concentration and memory
Respiratory	tachypnoea, shortness of breath, tightness in chest/throat, frequent sighing, yawning, feeling of suffocation/choking
Gastrointestinal	globus, dysphagia, epigastric discomfort, excessive air swallowing, dry mouth, belching, flatulence, nausea
Musculoskeletal	muscle pains, tremors, weakness, tetany of hands or feet (e.g. carpopedal spasm)
Psychological	tension, anxiety, panic, feelings of unreality or disorientation, fear of dying, fear of losing control or going crazy, hallucinations, phobias
General	fatigue, exhaustion, sleep disturbance, sweating, weakness, chills or heat sensations

Table 1: Signs and Symptoms of HVS by Body System

(Evans 2005; Porth and Litwack 2009; Caroline 2016; Clarke and Townsend 2016)

Assessment

The national ambulance service guidelines (Brown et al. 2016) advise that paramedics should presume that hyperventilation is secondary to an underlying respiratory or metabolic disorder until proven otherwise. Consequently, assessment of HVS patients requires comprehensive history taking and physical examination to exclude potential organic causes (Gardner 2003), which are displayed in Table 2.

BODY SYSTEM	DIFFERENTIAL DIAGNOSES	
Cardiovascular	• Angina • Aortic aneurysm • Coronary artery disease • Tachyarrhythmia	• Myocardial infarction • Pericarditis • Heart failure
Neurological	• Brain stem lesions • Encephalitis • Head trauma • Mèniére's disease	• Meningitis • Stroke • Vertigo
Respiratory	• Asthma • Chronic obstructive pulmonary disease	• Lung tumour • Pneumonia • Pneumothorax

	• Cystic fibrosis • Interstitial lung disease	• Pulmonary embolism • Pleural effusion
Gastrointestinal	• Cholecystitis • Liver failure • Hiatus hernia	• Liver cirrhosis • Peptic ulcer
Endocrine	• Diabetic ketoacidosis • Pheochromocytoma	• Thyrotoxicosis
Renal	• Kidney failure	
Environmental	• Heat or altitude acclimatisation	• Carbon monoxide poisoning
Other	• Anaemia • Drug intoxication • Drugs or caffeine (withdrawal) • Pain	• Hypokalaemia • Sepsis • Serious aspirin overdoses • Pregnancy

Table 2: Differential Diagnoses of HVS by Body System

(Pfeffer 1978; Brashear 1983; Ong et al. 2005; Pizzorno et al. 2016)

Questions during history taking should include whether the patient has previously suffered with episodes of hyperventilation, what the patient believes to have caused their anxiety and their past medical history (Brown et al. 2016; Clarke and Townsend 2016). The National Institute for Health and Care Excellence (2017) also suggests enquiring whether a patient's breathlessness is occurring at rest rather than exertion as this distinction points towards HVS.

Physical examination should include auscultation of breath sounds to exclude physical causes of breathlessness as may be indicated by a wheeze or crackles (Brown et al. 2016; National Institute for Health and Care Excellence 2017). Observation and palpation of the patient's chest should also be included as it may demonstrate paradoxical breathing associated with forced respiration i.e. abdomen retracts and upper chest expands on inhalation as supposed to normal abdominal protrusion and lower thorax expansion (Pizzorno et al. 2016).

Initial assessment should encompass measurement of respiratory rate, peripheral oxygen saturations (SpO_2), heart rate, blood pressure and temperature (National Institute for Health and Care Excellence 2017). Respiratory rate and heart rate will likely be elevated in acute HVS

patients alongside an abnormally high SpO_2 of 99% or 100% (O'Driscoll et al. 2017). Blood pressure and temperature should be within normal limits for the patient's age. In addition to these basic observations, disease specific measurements such as peak expiratory flow rate and an electrocardiogram (ECG) should be performed. Peak expiratory flow readings should be compared with predicted values according to patients' age, sex and height, in order to exclude significant respiratory restriction (Pizzorno et al. 2016). An ECG should also be performed as temporary ECG changes can occur during acute episodes of HVS and underlying cardiac conditions need to be excluded (Michaelides et al. 2010).

Diagnosis

The national ambulance service guidelines (Brown et al. 2016) recommend comparing patients' presentation to signs and symptoms of HVS, which are listed in Table 1. Despite Pizzorno et al. (2016) emphasizing that no symptoms are absolute diagnostic, the American Psychiatric Association (2013) provides guidance that HVS can be diagnosed in a patient that experiences a sudden onset of anxiety building up over several minutes in the presence of ≥4 of the underlined symptoms in Table 1.

To diagnose chronic HVS the Nijmegen questionnaire is frequently used; however, this is not suitable for diagnosing acute HVS (Pizzorno et al. 2016). In the absence of a standardised method of diagnosis, Pizzorno et al. (2016) suggest using end-tidal PCO_2 measurements obtained via nasal cannula to diagnose HVS; whereby, ≤ 30 mmHg during an acute episode acts as the cut-off point for HVS diagnosis. An alternative method is the breath holding time test as during an acute episode HVS patients are unable to hold their breath beyond 10-12 seconds so some clinicians use an arbitrary cut-off point of ≤ 30 seconds to diagnose HVS (Pizzorono et al. 2016).

The lack of agreement regarding specific HVS diagnostic criteria, led Smith (1985) to hypothesise that good patient-clinician relationships are more important than invasive laboratory tests (Jones et al. 2013). To promote a good patient-clinician relationship, Caroline (2016) suggests not adding to the patient's anxieties and trying to reassure patients. A solid basis for this is to communicate to patients that you believe they are suffering with HVS, which may offer sufficient reassurance and relief of anxiety to reduce the severity and frequency of symptoms (Boulding et al. 2016). On the flip side, delaying a diagnosis of HVS by referring patients for extensive testing or insisting they attend the Accident and Emergency (A&E) department following pre-hospital assessment may worsen their condition because of uncertainty and secondary anxiety over symptoms (Sharpe 2017).

Management

Management of HVS centres on reassuring patients and assisting them in establishing a good respiratory pattern (Kim 2005). Practical ways to achieve this are to breath with the patient, ask the patient to count to two between each breath or use distraction techniques (Caroline 2016). In clinical practice a method frequently observed is to verbally coach the patient to breathe in through their nose and out through their mouth in an effort to slow respirations down.

The national ambulance service guidelines (Brown et al. 2016) further suggest removing the source of the patient's anxiety or moving the patient to a different room if this is more practical. Oxygen therapy is not recommended unless patients are hypoxaemic with an $Sp0_2 < 94\%$; however, if this is the case then idiopathic HVS should no longer be considered as a working diagnosis due to this suggesting an underlying organic cause (Brown et al. 2016; O'Driscoll et al. 2017).

Paper bag rebreathing has not been recommended since 1990 due to the risk of hypoxia (Kishikawa 2015); although, evidence of its implementation can be found anecdotally in

current practice and in published literature (Set et al. 2004). Long-term, underlying anxiety can be addressed through psychotherapy or sedative drugs and breathing exercises performed during physiotherapy (Jones et al. 2013).

Relevance for Pre-Hospital Care

Patients with HVS use a significant amount of hospital and emergency service resources because they frequently seek care in the A&E department or from paramedics due to fearing they are experiencing life-threatening emergencies (Katerndahl and Realini 1995; Coley et al. 2009). In the general adult population HVS has an estimated prevalence of 6-10% (Thomas et al. 2001, 2005) rising to 34% in asthmatic patients (Grammatopoulou 2014). The national ambulance service guidelines (Brown et al. 2016) describe HVS as a common presentation in pre-hospital care but exact data on the prevalence of HVS in the pre-hospital setting has not yet been published. An unpublished service evaluation by Wilson et al. (2017) found a 1% prevalence of HVS in adult patients presenting to a UK ambulance service. This is comparable to published estimates for A&E departments, which range from 0.3% - 6% (Coley et al. 2009; Pfortmueller et al. 2015; Greenslade et al. 2017).

Attempts have been made to address the high economic cost of HVS patients presenting to ambulance services and A&E departments by educating doctors and utilising screening tools but they have been largely unsuccessful (Harvison et al. 2004). The literature shows that the utilisation of HVS screening tools is associated with low staff adherence rates and a reluctance of patients to participate, which highlights the need for a more personalised approach to HVS diagnosis and the benefit of GP involvement (Bokma et al. 2015). Nevertheless, a newly developed screening tool known as the Panic Screening Score, which has been specifically designed to detect HVS in the A&E setting in Canada, is currently being refined and validated in a prospective cohort study (Foldes-Busque et al. 2013).

A successful attempt at reducing pressures on A&E staff and improving HVS patients' symptoms is described by Pinney et al. (1987) in the form of an outpatient-based hyperventilation clinic run by staff nurses. However, this pilot study has not resulted in further research projects or been adopted into standard practice judging by the lack of recent literature on this topic. Nevertheless, this study again highlights the benefit of personalised care for HVS patients in a non-emergency setting.

Conclusion

In summary, a diagnosis of HVS is a diagnosis of exclusion of organic causes following detailed history taking and physical examination. HVS is self-limiting and treatment focuses on establishing a good respiratory pattern in order to normalise patients' observations and reduce their symptoms.

Previous attempts at reducing the high economic cost of HVS patients to A&E departments have either been unsuccessful or have not been adopted into standard practice. Consequently, Pfortmueller et al. (2015) propose that paramedics are ideally placed to diagnose and treat HVS pre-hospitally to avoid unnecessary and costly admissions to A&E departments. This is in line with the UK national ambulance service guidelines (Brown et al. 2016), which advise that HVS patients can be considered for non-conveyance as long as this is not their first HVS episode and symptoms have settled. Further research is needed to evaluate the pre-hospital prevalence and diagnostic accuracy for HVS, as well as identify clear diagnostic criteria and possible pre-hospital screening tools.

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