Dyspnea – pathophysiology, types. Sleep apnea syndrome.

Blagov Marinov, MD, PhD
Pathophysiology Dept.,
Medical University of Plovdiv

Dyspnea, the sensation of breathlessness or inadequate breathing, is the most common complaint of patients with cardiopulmonary diseases.
Definitions

- The conscious awareness of the labored breathing or air hunger in conditions other than heavy exercise
- The subjective sensation of breathlessness
- An awareness of breathing that is both unpleasant and unanticipated

Terms and synonyms

\[
\begin{align*}
\text{Synonymous} \\
\{ & \text{Breathlessness}, \\
& \text{Short of Breath (SOB)}, \\
& \text{Dyspnoea} \\
\}
\end{align*}
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“..a subjective experience of breathing discomfort that is comprised of qualitatively distinct sensations that vary in intensity” (ATS consensus statement 1999)

\[
\begin{align*}
\{ & \text{Air Hunger}, \\
& \text{Sense of Work/Effort}, \\
& \text{Chest tightness} \\
\}
\end{align*}
\]

At least 3 distinguishable qualities
Patients’ description of dyspnea
The “language” of dyspnea

- “I feel like I am suffocating.”
- “I am afraid and feel like I am drowning.”
- “I have a tightness in the chest”

Other conditions
often confused with dyspnea

- **Tachypnea** (e.g. increased breathing rate caused by fever)

- **Hyperpnea** (increased ventilation through metabolic acidosis e.g. diabetic ketoacidosis)

- **Hyperventilation** (Psychologically induced increased respiration)
Effects of dyspnea on the patient

- Reduction in:
  - general health status
  - activities of daily living (functional capacity)
  - quality of life (QoL)

- Although dyspnea is subjective, the effects on function are objectively observable and measurable

**Neural pathways for air hunger**

- AH → Cortex → Midbrain
- Midbrain → Brainstem Resp. pacemaker
- Brainstem Resp. pacemaker → Lung Mechanoreceptors
- Brainstem Resp. pacemaker → Respiratory muscles
- Brainstem Resp. pacemaker → Central Chemoreceptors
- Brainstem Resp. pacemaker → Peripheral Chemoreceptors
- PCO₂ ↑ → Central Chemoreceptors
- PO₂ ↓ → Peripheral Chemoreceptors
- Vₑ ↑
Acute Dyspnea

- **Pulmonary Causes**
  - **Traumatic Causes**
    - pneumothorax, hemothorax, pulmonary contusion, flail chest, cardiac tamponade, and diaphragmatic perforation or rupture, neurologic injury
  - **Nontraumatic Causes of Dyspnea**
    - Pulmonary Embolus
    - Asthma
    - Pneumonia
    - Pleural Effusion
    - Acute Lung Injury

- **Mechanical Obstruction of the Airway**
  - Obstruction may result from the position of head, the tongue, aspiration of vomitus, or a foreign body.
  - Opening the airway with the head tilt-chin lift maneuver may solve the problem.
Acute Dyspnea

- **Cardiac Causes**
  - Acute Cardiogenic Pulmonary Edema

- **Other Causes** of Acute Dyspnea
  - Psychogenic Dyspnea (hyperventilation syndrome)
  - Guillain-Barré Syndrome
  - Myasthenia Gravis

Chronic Dyspnea

- **Pulmonary Causes**
  - Chronic Obstructive Pulmonary Disease
  - Bronchial Asthma

- **Cardiac Causes**
  - Valvular Heart Disease
  - Mitral Stenosis
  - Mitral Regurgitation
  - Aortic Stenosis

- **Other Causes** of Chronic Dyspnea
  - Abdominal Loading
  - Neuromuscular Disorders
Pulmonary Etiology

- COPD
- Asthma
- Restrictive Lung Disorders
- Hereditary Lung Disorders
- Pneumonia
- Pneumothorax
Dyspnea in COPD: hyperinflation

- Smaller zone of apposition
- Decrease in the curvature of the diaphragm
- Increased elastic recoil of the thoracic cage
- Worsening of the length-tension relationship

Dyspnea in COPD: respiratory pressure generation

- Inspiratory muscles adapted to hyperinflation (shortening of diaphragmatic sarcomeres, decrease in number)
- Parallel reductions in maximal inspiratory and expiratory pressures: generalised muscle weakness
  - Electrolyte disturbances
  - Blood gas abnormalities
  - Cardiac decompensation
  - Weight loss with muscle waisting
  - Steroid myopathy
Cardiac Etiology

- CHF
- CAD
- MI (recent or past history)
- Cardiomyopathy
- Valvular dysfunction
- Left ventricular hypertrophy
- Pericarditis
- Arrhythmias

Mixed Cardiac/Pulmonary Etiology

- COPD with pulmonary HTN and/or cor pulmonale
- Deconditioning
- Chronic pulmonary emboli
- Pleural effusion
Noncardiac or Nonpulmonary Etiology

- Metabolic conditions (e.g. acidosis)
- Pain
- Trauma
- Neuromuscular disorders
- Functional (anxiety, panic disorders, hyperventilation)
- Chemical exposure

Psychogenic Dyspnea
(hyperventilation syndrome)

- Dyspnea 50% to 90%
- The diagnosis may be suggested if the **objective findings are inconsistent with the patient's subjective complaints**.
- Although stress may aggravate dyspnea of any cause, dyspnée clearly related to emotional stress suggests psychogenic dyspnea.
- Often unrelated to exertion
- More often in women than in men
Hyperventilation

- Overbreathing resulting in a decrease in the level of carbon dioxide
- Signs and symptoms
  - Anxiety
  - Numbness
  - A sense of dyspnea despite rapid breathing
  - Dizziness
  - Tingling in hands and feet

Easily Performed Diagnostic Tests

- Chest radiographs
- Electrocardiograph
- Screening spirometry
Further investigations

- In cases where test results inconclusive
  - complete PFTs
  - ABGs
  - EKG
  - Standard exercise treadmill testing/ or complete cardiopulmonary exercise testing
  - Consultation with pulmonologist/cardiologist may be useful

ABGs

- Commonly used to evaluate acute dyspnea
- Can provide information about altered pH, hypercapnia, hypocapnia or hypoxemia
- Normal ABGs do not exclude cardiac/pulmonary dx as cause of dyspnea
  - Remember- ABGs may be normal even in cases of acute dyspnea - ABGs do not evaluate breathing
PULSE OX

- Rapid, widely available, noninvasive means of assessment in most clinical situations -
  - insensitive (may be normal in acute dyspnea)
- The % of Oxygen saturation does not always correspond to \( \text{PaO}_2 \)
- The hemoglobin desaturation curve can be shifted depending on the pH, temperature or arterial carbon monoxide or carbon dioxide levels

Signs and Symptoms I

- Difficulty breathing
- Altered mental status
- Anxiety or restlessness
- Increased or decreased respirations
- Increased heart rate
- Irregular breathing
- Cyanosis
Signs and Symptoms II

- Pale conjunctivae
- Abnormal breath sounds
- Difficulty speaking
- Use of accessory muscles
- Coughing
- Tripod position
- Barrel chest

Management of dyspnea

- There is no one specific cause of dyspnea and no single specific treatment

- Treatment varies according to patient’s condition
  - chief complaint
  - history
  - exam
  - laboratory & study results
Interventions

- Treat immediate life threats
- Possible interventions
  - Oxygen via nonrebreathing mask at 15 L/min
  - Positive pressure ventilations
  - Airway adjuncts
  - Positioning
  - Respiratory medications

Sleep Apnea Syndrome (SAS)

Blagoi Marinov, MD, PhD
Pathophysiology Dept.,
Medical University of Plovdiv
Physiology of Normal Sleep

- 2 Phases:
  - REM
  - Non-REM Sleep

Non-REM Sleep

- 4 stages of progressively deeper sleep
- Normal muscle tone
- Associated with increased 5HT (serotonin)
- Decreased autonomic activity:
  - Lower BP, Pulse, respirations slow
NREM Sleep: Theories of its purpose…

- The decrease in metabolic demand on the brain during NREM allows glycogen stores to replenish
- Allows for consolidation of memories and learning

REM (dreamland)

- 10-20 min. cycles consisting of:
  - Rapid Eye Movements
  - ElectroEncephalogram shows fast activity very similar to wakeful EEG pattern
  - Suppression of peripheral muscle tone
  - Often increased autonomic tone - ie, increased blood pressure, resp, heart rate
- Where dreaming occurs
Normal Sleep Pattern

- Sleep cycles between NREM and REM approx. 4-5 times/night
- Cycles last approx. 90min
- REM duration and frequency increase thru night
- Proportion of slow wave sleep (stages 3,4) decreases thru night

Normal Sleep Distribution

- REM sleep accounts for approximately 25% of total sleep time
- Non-REM sleep accounts for 75% of sleep time, with 25% of that spent in Stages 3,4 (most restful portion)
Age-Related Changes

- Decreases in dreaming, total sleep time, REM, and slow-wave (deep sleep)
- Increases in early morning awakening, fragmentation, daytime napping, and phase advancement—
  - i.e., earlier to bed, and awaken earlier

Borbély, Tobler, Achermann, Geering, In: Bits of sleep, 1998
The Polysomnography
“measuring” sleep

- EEG, ECG
- EOG (oculogram)
- Chin EMG (myelogram)
- Ant. Tibialis EMG
- Pulse Oxymeter
- Blood Pressure

Sleep Disorders- 2 Divisions

- **Dyssomnias**- disorders of quality, timing, or amount of sleep (quantity)
- **Parasomnias**- abnormal behaviors associated with sleep or sleep-wake transition, that often produce arousals e.g. nightmares, sleep walking, sleep talking
Dyssomnias

- Primary Insomnia
- Narcolepsy
- Sleep Apnea
- Circadian Rhythm Sleep Disorder (jet lag, et al.)
- Restless Legs Syndrome (RLS)
- Medical/Substance related insomnia

Parasomnias

- Disturbances in arousal and sleep stage transition that intrude into the sleep process
- 2 types:
  - Those that occur during rapid eye movement (REM) sleep (Nightmares)
  - Those that occur during non-rapid eye movement (NREM) sleep (sleep terrors)
Three forms of Sleep Apnea

- **CENTRAL Sleep Apnea (20%)**
  - No respiratory effort, no nasal airflow, lack of neural input from CNS.
  - Snoring less common
  - Developmental phenomenon

- **OBSTRUCTIVE Sleep Apnea (out of phase)**
  - The most common form of Apnea
  - ↑ respiratory effort, no nasal airflow
  - Caused by upper airway obstruction
  - Respiratory movements persist

- **MIXED (OSA + CSA)**
  - Both obstructive and central

Obstructive Sleep Apnea

- **General Characteristics**
  - Excessive Daytime Sleepiness and Daytime Functional Impairment
  - ≥ 5 apneic or hypopneic events/hour while sleeping with continued respiratory effort in a symptomatic patient
  - ≥ 15 apneic or hypopneic events/hour in an asymptomatic patient
Definitions

- Apnea is cessation or near cessation of flow (inspiratory flow decreases to < 20%) ≥ 10 seconds
- Hypopnea is continued breathing, but ventilation decreases by 50% for ≥ 10 seconds
- Apnea-Hypopnea Index (AHI) – total number of apneas and hypopneas per hour of sleep

Epidemiology

- 1 in 5 adults has mild OSA, AHI > 5
- 1 in 15 adults has moderate or severe OSA, AHI >15
- Predisposing factors
  - Male sex (85% men)
  - BMI >30
  - Shortened mandible and/or maxilla
  - Hypothyroidism
  - Acromegaly
RISK FACTORS

- Obesity
- Age
- Sex
- Race
- Craniofacial anatomy
- Smoking and alcohol consumption

OBESITY

- Strongest risk factor for OSA
  - Present in > 60% of patients referred for a diagnostic sleep evaluation
  - Wisconsin Sleep Cohort Study
    - A one standard deviation difference in BMI was associated with a 4-fold increase in disease prevalence
Obesity

- Alters upper airway mechanics during sleep
  1. Increased parapharyngeal fat deposition:
     - neck circumference: ≥ 17” males
     - > 16” females
     With subsequent:
     → smaller upper airway
     → increase the collapsibility of the pharyngeal airway

Obesity

2. Changes in neural compensatory mechanisms that maintain airway patency:
   → diminished protective reflexes which otherwise would increase upper airway dilator muscle activity to maintain airway patency
Obesity

3. waist circumference

Fat deposition around the abdomen produces

→ reduced lung volumes (functional residual capacity) which can lead to loss of caudal traction on the upper airway

→ low lung volumes are associated with diminished oxygen stores

Pathophysiology
OSA - Complications

- Cardiac Problems
  - Abnormal heart rhythms, heart attack and heart failure
- High Blood Pressure
- Memory Problems and inability to think correctly
- Stroke
- Increased insulin resistance (often in non-diabetic patients)
- Increased traffic and workplace accidents
Diagnosis

- Sleep history
- Obesity, jaw structure, upper airway anatomy, BP
- Sleep Questionnaires
- Polysomnography

Diagnosis - options:

- Attended Polysomnography
  - Standard of practice
- Unattended Home Polysomnography
  - Only if medical conditions preclude attended study
- Overnight Oximetry
  - Not considered adequately sensitive
Polysomnography

- Measurements
  - EEG, EOG, submental EMG – used to identify stages of sleep
  - Airflow – measured by nasal prongs with pressure transducer, give a quantitative measure of inspiratory airflow
  - Respiratory Effort
  - O2 saturation
  - ECG
  - Body position
  - Anterior tibialis EMG – to detect limb movements

- Derived Information
  - Total Sleep Time
  - Sleep Efficiency
  - Sleep stage latency
  - Sleep stage distribution
  - Arousals
  - Apneas
  - Hypopneas
  - Indices
  - Snoring
  - Body position
  - Oxygen desaturations
  - Limb Movements

Obstructive Apnea

![Graph showing EEG, Airflow, Effort (Rib Cage), Effort (Abdomen), Effort (Pes), and SaO2 over time with an arousal marker.](https://example.com/graph.png)

2006 American Academy of Sleep Medicine
Central Apnea

- EEG
- Arousal
- Airflow
- Effort (Rib Cage)
- Effort (Abdomen)
- Effort (Pes)
- SaO₂

Polysomnography

- Split studies
  - Establish diagnosis in first half of the night, determine CPAP setting in second half
  - Criteria
    - AHI ≥ 40 events per hour for ≥ 2 hours
    - CPAP titration occurs over 3 hours as obstructive events increase through the night
    - Elimination or near-elimination of obstructive events in REM and non-REM sleep in supine position
Treatment

- Conservative Therapy - Weight loss, avoid alcohol and other sedative drugs (BZD)
- Nasal Continuous Positive Airway Pressure (CPAP)
  - Most effective treatment
- Oral Appliances
- Surgery

Constant positive airway pressure (CPAP)

- Indications
  - Based on AHI
    - CMS: AHI >15 events/h or with AHI 5-14 events/h with clinical sequelae (excess daytime sleepiness, cognitive impairment, mood DO, insomnia, cardiovascular dis.)
    - Consider CPAP in patients with lower AHI (~5) who have symptoms, perform mission critical work (pilots, bus drivers)
- Mechanism
  - Splints open the upper airway to prevent airway collapse
Positive Airway Pressure

CPAP Devices
Oral Appliances

- Mandibular Repositioning Splint
  - Protrude the mandible forward and hold tongue more anteriorly, away from the posterior pharyngeal wall
  - More effective in patients with mild – moderate OSA, AHI 5-15 events/h

Surgical treatment

- Adjustment of:
  - Uvula
  - Soft palate
For a good night sleep!