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Evaluation of the Dyspneic Patient

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Objectives: **To define dyspnea and to describe a) mechanisms and causes for dyspnea, b) current classification schemes, and c) evaluation and management of the dyspneic patient.**

The dyspneic patient often presents with a complaint of "breathlessness" or "shortness of breath" with activity - a subjective description of uncomfortable breathing.

Although various classification schemes have been devised for dyspnea, it is sometimes difficult from the history and examination, as well as preliminary screening studies to accurately diagnose why symptoms are occurring.

Disorders of several different organ systems, including the lung, pleura, airway, heart, pericardium, neuromuscular system, and vasculature may cause dyspnea. Moreover, anemia, metabolic disorders and psychogenic causes must be considered.

A systematic approach to evaluation and management is essential.

DYSPNEA

Strict interpretation: disordered(*dys-*) breathing (-*pnea*).

Conceptually: "It is a difficult, labored, uncomfortable breathing, although it is not painful in the usual sense of the word. It is subjective and, like pain, it involves both perception of the sensation by the patient, and his reaction to the sensation [Comroe 1966]."

Factors that can mediate reactions to dyspnea include cultural background, environment, life experiences and psycological states [McCord 1992]. Adaptation to dyspnea depends on the individual, and while some patients may simply modify there activity level to minimize dyspnea, others become so decompensated they require evaluation in an emergency room setting.

Mechanism

The sensation of dyspnea arises from afferent impulses from various sensory receptors and higher centers (Table 1.) A detailed review of causes and mechanisms at the receptor level has been published [Nisell 1991].

Classification

Classifications for the rating of dyspnea or breathlessness include the following [Borg 1982, Mahler 1987]:

1. Medical Research Council scale, which uses a five point intensity rating (Table 2).

2. Oxygen-Cost Diagram, which is a vertical 100-mm line that represents graded activity levels.

3. Baseline Dyspnea Index, which uses three categories based on functional impairment, magnitude of task, and magnitude of effort.

4. American Thoracic Society questionnaire for rating breathlessness [Altose 1985].

Several other instruments for classifying dyspnea have been described [McCord 1992]. Unexplained chest pain with accompanying breathlessness has also been explored [Bass 1991]. Measurement of dyspnea with exercise may also be useful [Mahler 1992].

Causes

Approximately two thirds of patients will have a pulmonary or cardiac cause for their dyspnea. Most causes for dyspnea are summarized in Table 3.

APPROACHES TO EVALUATION

Commonly one of three unsatisfactory approaches to dyspnea is taken by the clinician [Pratter 1991].

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Table 1. Receptors Hypothesized to Contribute to Dyspnea [Gillespie 1994].

Mechanoreceptors (vagal afferent)	Aortic bodies
Lung	Central medullary chemoreceptors
Stretch receptors	
J receptors	Central nervous system
Respiratory muscles	Efferent signals to respiratory muscles
Muscle spindle (intercostal)	
Golgi tendon organ (diaphragm)	Vasovagal receptors
Airway (irritant receptors)	Right atrial Mechanoreceptors
	Left atrial Mechanoreceptors
Chemoreceptors	Pulmonary artery baroreceptors
Carotid bodies	Right ventricular strain receptors

The first is "intuitive" or making a diagnosis without objective data - e.g. assuming because a patient is a smoker they must have COPD as a cause for their dyspnea; the second "search and destroy" or pursing one potential cause exhaustively before moving on to the next potential cause - e.g. proceeding with exhaustive cardiovascular studies before obtaining simple spirometry; and three, "hunt and peck" or evaluating and treating for one disorder after another in the hope of stumbling upon the correct diagnosis.

Because dyspnea is a subjective reporting by the patient or family, or simply an observation by the clinician or nurse during evaluation for other problems, a systematic approach must be taken to evaluating and managing. Dyspnea often is a presenting problem for primary care physicians (both pediatric and adult), emergency physicians, subspecialists in allergy, cardiology, endocrinology, intensive care, and thoracic disease, as well as several surgical specialties.

Table 2. Medical Research Council 5 Point Scale [Borg, 1982, Mahler 1987].

0	Not troubled with breathlessness except during strenuous exercise.
1	Troubled by shortness of breath when hurrying on the level or walking up a slight hill.
2	Because of breathlessness, walks slower on the level than other people of the same age, or must stop for breath when walk ing at own pace on the level.
3	Stops for breath after walking about 100 yards or after walking a few minutes on the level.
4	Too breathless to leave the house or breathless when dressing or undressing.

ASSESSMENT OF PATIENTS WITH DYSPNEA

The following initial evaluation is essential:

1. Determine specific activities that cause breathlessness.

2. Document exposures (i.e. workplace, farm, hobbies, animals and birds).

3. Review medications (think about drug-induced pulmonary conditions).

4. Inquire about past medical diseases, trauma, and surgery.

5. Comprehensive cardiopulmonary examination.

6. Screening studies, including electrocardiogram, chest x-ray, hemoglobin concentration, thyroid function and spirometry.

If the above is unrevealing for a cause of dyspnea, more specific testing is required to diagnose obstructive or restrictive airway disease, pulmonary hypertension, pulmonary emboli, mitral and aortic valve disease, pericardial effusion or tamponade, pericarditis, and ventricular dysfunction (Table 4).

Asthma is commonly a cause for dyspnea especially in those patients whose cause for dyspnea remains unexplained after history, physical examination,

Table 3. Causes for Dyspnea [Gillespie 1994].

- Pulmonary
  - Airway
  - Asthma
  - Bronchiolitis obliterans
  - Chronic bronchitus
  - Laryngeal disease
  - Tracheal stenosis
  - Tracheomalacia
- Parenchymal
  - Acute alveolitis
  - Drug-induced conditions
  - Emphysema
  - Lymphangitic carcinomatosis
  - Metastatic disease
  - Pneumonitis
  - Pulmonary edema
  - Pulmonary fibrosis
- Pleural or chest wall
  - Abdominal distention
  - Chest wall injury
  - Effusion
  - Fibrothorax
  - Kyphoscoliosis
  - Pleural mass
  - Pnemothorax
- Vascular
  - Pulmonary hypertension
  - Thromboembolic disease
  - Vasculitis
  - Veno-occlusive disease
- Neuromuscular
  - CNS disorders
  - Myopathy and neuropathy
  - Phrenic nerve and diaphragmatic disorders
  - Spinal cord disorders
  - Systemic neuromuscular disorders
- Cardiac
  - Arrhythmia
  - CAD
  - Intracardiac shunt
  - Left ventricular failure
  - Myxoma
  - Pericardial disease
  - Valvular disease
- Other
  - Anemia
  - Deconditioning
  - Gastroesophageal reflux
  - Hyperthyroidism or hypothyroidism
  - Metabolic acidosis
  - Psychogenic

chest x-ray and spirometry. Pharmacologic bronchoprovocation challenge (BPC) is useful in identifying these patients [Pratter 1991].

Pratter reported on one hundred consecutive patients referred to a pulmonary disease clinic [Pratter 1989]. Causes included asthma (25%), interstitial lung disease (12%), COPD (12%), cardiomyopathy (9%), upper airway disease (7%), deconditioning (4%), GER (4%), psychogenic (4%), extrapulmonary (3%) and other (5%).

Depaso reported on seventy-two patients who were referred by other physicians (over a seven year period) for dyspnea greater than one month duration, unexplained by history, physical examination, chest roentgenogram and spirometry [Depaso 1991]. Frequency of individual causes are shown in Table 5.

A definite cause for dyspnea was found in 58 patients (81%), and no answer was found in 14 patients (19%). Dyspnea was due to pulmonary disease in 36%, cardiac disease in 14% and extrathoracic

Table 4. Specific Testing for Unexplained Dyspnea [Gillespie 1994].

- Pulmonary
  - Flow-volume curves
  - Total lung capacity
  - Carbon monoxide diffusing capacity of the lungs
  - Oximetry or arterial blood gasses during exercise
  - Bronchoprovocation testing
  - Maximal inspiratory and expiratory respiratory pressures
- Vascular
  - Ventilation-perfusion lung scanning
  - Venous studies of the legs
- Cardiac
  - Echocardiography
- Additional Procedures for Difficult Cases
  - Cardiopulmonary exercise testing
  - Monitoring of cardiac rhythm
  - Radionuclide cardiac studies
  - Right or left heart catheterization
  - Pulmonary angiography
  - High-resolution computed tomographic scanning of the chest
  - Lung biopsy
  - Monitoring of esophageal pH (24 hour study)

Table 5. Causes for Chronic Dyspnea in 72 Specialty-Referred Patients [Depaso 1991].

- Respiratory disease
  - Airway obstruction
    - Asthma/reactive airway disease (n=12)
    - Endobronchial malignancy (n=1)
    - Extrathoracic upper airway obstruction (n=1)
  - Parenchyma
    - Interstitial lung disease (n=2)
    - Bullous disease (n=2)
    - Chronic lower resp. bacterial infection (n=1)
  - Pulmonary vascular
    - Pulmonary embolism (n=3)
    - Primary pulmonary hypertension (n=1)
  - Respiratory muscle weakness
    - Myasthenia gravis (n=1)
    - Lower motor neuron disease (n=1)
  - Chest wall
    - Pectus deformity (n=1)
- Cardiac Disease
  - Myocardial
    - CAD (n=4)
    - Cardiomyopathy (n=2)
  - Conduction
    - Arrhythmias (n=2)
    - Intracardiac shunt (n=1)
    - Constrictive pericarditis (n=1)
- Central Nervous System
  - Hyperventilation Syndrome (n=14)
- Thyroid Disease
  - Thyrotoxicosis (n=1)
  - Myxedema (n=1)
- Kidney
  - Metabolic acidosis (n=1)
- Gastrointestinal reflux (n=3)
- Deconditioning (n=2)
- Unexplained (n=14)

disease in 4%.

Their conclusions were as follows:

1. Most but not all patients will have a recognizable disease to explain their dyspnea.

2. The disease spectrum is extensive resulting in a very broad differential diagnosis.

3. Neither the duration nor severity of dyspnea provided diagnostic insight.

4. Age younger than 40 years, intermittent dyspnea, and normal alveolar-arterial oxygen pressure difference (P[A-a]])O2 at rest breathing room air was strongly predictive of bronchial hyperactivity or hyperventilation.

5. With the exception of BPC, the diagnostic yield of any single non-invasive test was poor because of the large number of diagnosis seen in these patients.

6. All patients approaching diagnosis of "unexplained" or hyperventilation should have a BPC test.

7. Patients with a P(A-a)O2 <= 20 mm Hg are very unlikely to have occult pulmonary parenchymal or pulmonary vascular disease to explain their dyspnea.

ACUTE DYSPNEA CONSIDERATIONS

Acute dyspnea usually represents a sudden event that leads to pathophysiologic disturbances at rest. These include acute asthma, allergic reactions, upper airway obstruction, pneumothorax, pulmonary edema, pulmonary embolism, myocardial infarction, pericarditis, pericardial effusion, and sudden chamber wall or valvular injury following infarction.

These patients may be at acute risk and require prompt evaluation of oxygenation, supplemental oxygen support (and ventilation if necessary), as well as determination and correction of the underlying cause.

Oxygen Transport

Adequate tissue oxygenation depends on hemoglobin concentration, the percentage of hemoglobin saturated with oxygen in arterial blood (SaO2), cardiac output (CO), oxygen consumption (VO2), the affinity of hemoglobin for oxygen (P50) and the distribution of perfusion.

Normal compensatory mechanisms are typically disturbed in critically ill patients, and shifts in the oxyhemoglobin dissociation curve (Fig. 1) such as from acidosis or alkalosis may profoundly impact oxygen content and delivery.

The curve may be shifted to the right with improved oxygen unloading (decrease in the affinity of hemoglobin for oxygen) at the tissue level by

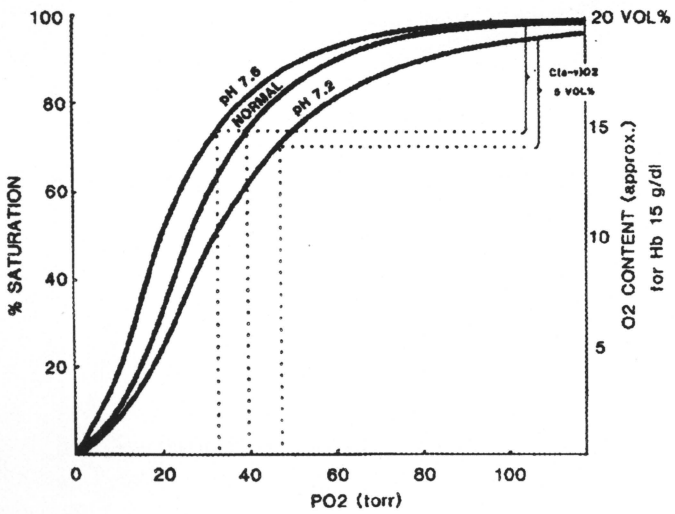

Figure 1. Oxygen dissociation curve [Snyder 1987].

increased blood temperature, carbon dioxide, hydrogen ion concentration, 2,3-DPG, intercellular sodium, and hemoglobin concentration.

The curve may be shifted to the left by hypothermia, hypocarbia, alkalosis, anemia, and decreases in 2,3-DPG or sodium.

Although methods exist for approximating oxygen consumption in critically ill patients, they are technically difficult and may not give clue to individual organ metabolism. In summary, it is best simply to maximize oxygen transport to support the greater than normal metabolic rates.

Tissue oxygenation depends on both oxygen saturation and rate of flow:

$$DO_2 = CO \times CaO_2 \times 10 \text{ (ml/min)}$$

DO_2 is oxygen delivery, CO is cardiac output and CaO_2 is arterial oxygen content.

If cardiac output is severely depressed despite improvement in arterial oxygenation, oxygen transport may be worsened. It is necessary to consider all factors that contribute to oxygen supply and not rely solely on the level of arterial oxygen saturation improvement [Edwards 1993], [Snyder 1987].

Oxygen Consumption (VO_2)

The amount of oxygen utilized is normally determined by the body's energy requirements, and can be calculated from the Fick equation [Dantzker 1991]:

$$VO_2 = VI \times FIO_2 - VE \times FEO_2$$
$$= CO \times (CaO_2 - CvO_2) \times 10$$

VI and VE are the inspired and expired minute ventilations, FIO_2 and FEO_2 are the inspired and expired fractional concentrations of oxygen, CO is the cardiac output, and CaO_2 and CvO_2 are the arterial and mixed venous oxygen content.

In a steady state condition the amount of oxygen taken up by the tissues is equal to the amount taken up in the lung, so that VO_2 can be calculated from either the gas side of the system, measuring the difference between the amount of oxygen in the inspired and mixed expired gas, or the blood side as the product of the cardiac output and the arterial-venous oxygen difference.

Pulse Oximetry, Mixed Venous Oxygen Tension, Continuous Venous Oximetry

Pulse oximetry is commonly used for measuring arterial oxygen saturation (SaO_2) (Fig. 2).

It is based on the principle that oxyhemoglobin and reduced hemoglobin have different light absorbance characteristics.

Drawbacks include false-high readings when high carboxyhemoglobin or methemoglobin. Other false readings with jaundice, skin color, nail polish, shock and severe hypoxia.

Mixed venous oxygen tension (PVO_2) may be the most reliable single physiologic indicator for monitoring the overall balance between oxygen supply and demand.

Mixed venous blood is a flow-weighted mixture of all blood that has traversed the systemic vascular beds and may best be sampled from the proximal pulmonary artery.

Marked venous hypoxemia ($PVO_2 < 27$ mmHg) and lactic acidosis is associated with high mortality.

Figure 2. The Nellcor® Pulse Oximeter.

Table 6. Interpreting Arterial Blood Gases.

Condition	Findings	Cause
Respiratory Acidosis	(PaC02 > 45) + (pH < 7.35)	Inadequate ventilation
Metabolic Acidosis	(PaC02 < 35) + (pH < 7.35)	H+ buildup
Respiratory Alkalosis	(PaC02 < 35) + (pH > 7.45)	Increased ventilation
Metabolic Alkalosis	(PaC02 > 45) + (pH > 7.45)	Volume depletion or low K+

Mixed venous oxygen tension does not indicate if a specific organ is under perfused or the distribution of perfusion. Another drawback is that in critically ill patients the central venous sample may not represent a true mixed venous sample.

Fiberoptic catheters for continuous analysis of blood oxygen saturation (SvO_2) has increased in popularity since first introduced in 1972 (Fig. 3). The SvO_2 reflects the overall balance between oxygen supply and demand. Calibration with a mixed venous sample and catheter position are important.

The normal range is 0.68-0.77. High values indicate an increase in delivery relative to consumption, and is associated with cirrhosis, sepsis, peripheral left-to-right shunting, cyanide toxicity, arterial hyperoxia or technical problems (calibration error, wedging of the catheter).

Low values may be associated with anemia, arterial oxygen desaturation, increased oxygen consumption or decreases in cardiac output. A rapidly falling Sv02 may proceed a major cardiovascular complication.

Interpreting arterial blood gases for acid-base balance is also important, and Table 6 allows for distinguishing respiratory from metabolic disorders [American Heart Association 1987].

[Martin 1992], [Nelson 1987], [Nelson 1992], [Snyder 1987], [Vincent 1992].

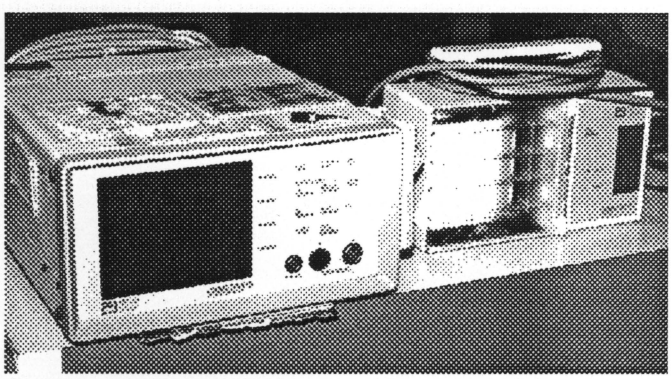

Figure 3. The Abbott Oximetrix® for measuring continuous mixed venous oxygen saturation.

TREATMENT OF DYSPNEA

Foremost in treatment of the acute or chronic dyspneic patient is correction of the underlying cause. Recognition and intervention in acute dyspnea may be life saving, while treatment of chronic dyspnea may improve quality of life.

An excellent review of evaluation and treatment of dyspnea in elderly patients has been published [Silvestri 1993].

Tobin reviews use of brochodilator therapy, diazepam in COPD patients, opiates, oxygen therapy and sitting near an open window or fan in care of dyspneic patients [Tobin 1990].

REFERENCES

Altose MD. Assessment and management of breathlessness. Chest 88(Suppl 2):77S-83S, 1985

Bass C: Unexplained chest pain and breathlessness. Med Clin of No Amer 75(5):1157-1173, 1991

Borg GAV. Psychophysical bases of perceived exertion. Med Sci Sports Exerc 14:377-381, 1987

Comroe JH: Some theories of the mechanism of dyspnea. In Howell JB, Cambell EJM (eds.): Breathlessness. Boston, Blackwell Scientific Publications., 1966, p1

Dantzker DR: Cardiopulmonary Critical Care, second edition. Philadelphia, W.B. Saunders Company, 1991

DePaso WJ, Winterbauer RH, Lusk JA, Dries DF,

Springmeyer SC: Chronic dyspnea unexplained by history, physical examination, chest roentgenogram, and spirometry. Chest 100(5):1293-1299, 1991

Edwards JD, Shoemaker WC, Vincent JL: Oxygen Transport. London, W.B. Saunders Company Ltd, 1993

Gillespie DJ, Staats BA: Unexplained dyspnea. Mayo Clin Proc 69:657-663, 1994

Martin C, Auffray JP, Badetti C, Perrin G, Papazian L, Gouin F: Monitoring of central venous oxygen saturation versus mixed venous oxygen saturation in critically ill patients. Intensive Care Med 18:101-104, 1992

Maylor DA, Rosiello RA, Harver A, Lentine T, McGovern JF, Daubenspeck JA. Comparison of clinical dyspnea ratings and psychophysical measurements of respiratory sensation in obstructive airway disease. Am Rev Respir Dis 135:1229-1233, 1987

Mayler DA, Horowitz MB: Clinical evaluation of exertional dyspnea. Clin in Chest Med 15(2):259-269, 1994

McCord M, Cronin-Stubbs D: Operationalizing dyspnea: Focus on measurement. Heart & Lung 21(2):167-179, 1992

Nelson LD: Application of venous saturation monitoring, In Critical Care. Edited by JM Civetta. Philadelphia, J. B. Lippincott, 1992, pp 283-290

Nelson LD: Mixed venous oximetry, In Oxygen Transport and the Critically Ill. Edited by JV Snyder. Chicago, Year Book Publishers, 1987, pp 179-198

Nisell, O: Causes and mechanisms of breathlessness. Clin Physiol 12:1-17, 1992

Pratter MR, Curley FJ, Dubois J: Cause and evaluation of chronic dyspnea in a pulmonary disease clinic. Arch Intern Med 149:2278, 1989

Pratter NR, Bartter T: Dyspnea: Time to find the facts. Chest 100(5) 1187, 1991

Silvestri GA, Mahler DA: Evaluation of dyspnea in the elderly patient. Clin in Chest Med 14(3):393-404, 1993

Snyder JV, Pinsky MR: Oxygen Transport in the Critically Ill. Chicago, Year Book Medical Publishers, Inc., 1987

Snyder JV: Assessment of systemic oxygen transport, In Oxygen Transport and the Critically Ill. Edited by JV Snyder. Chicago, Year Book Publishers, 1987, pp 179- 198

Snyder JV: Oxygen transport: the model and reality, In Oxygen Transport and the Critically Ill. Edited by JV Snyder. Chicago, Year Book Publishers, 1987, pp 3-15

Snyder JV: Pulmonary physiology, In Oxygen Transport and the Critically Ill. Edited by JV Snyder. Chicago, Year Book Publishers, 1987, pp 295-317

Tobin MJ Dyspnea: Pathophysiologic basis, clinical presentation and management. Arc Intern Med 150:1604-1613, 1990

Vincent JL: Does central venous oxygen saturation accurately reflect mixed venous oxygen saturation? Nothing is simple, unfortuantely. Intensive Care Med 18:386-387, 1992