Chapter 3

Respiratory System Tests

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§3.1 Arterial Blood Gas Study, Exercise

Relevant Social Security Medical Listings

- Listing 3.02 Chronic Pulmonary Insufficiency (Adults)
- Listing 103.02 Chronic pulmonary Insufficiency (Children)
- Listing 3.06 Pneumoconiosis (Adults)

Other Names

Cardiopulmonary Exercise Testing, Exercise Blood Gases

Type

Objective/Physiological Test (Pulmonary)

Can SSA Purchase?

Yes. However, this test should be ordered by the SSA only if all other methods of possible allowance of a disability claim have been eliminated.

Purpose

Detect, evaluate, and assess the severity of pulmonary limitation of exercise capacity in the presence of symptoms (usually dyspnea[1]) out of proportion to non-exercise (static) pulmonary tests such as spirometry, carbon monoxide diffusing capacity (DLCO), and resting arterial blood gas studies (ABGS).

Contraindications

Note that in addition to the other contraindications to exercise testing associated with a treadmill or bicycle ergometry, severe pulmonary disease can contraindicate exercise ABGS. A person with obviously advanced pulmonary impairment based on **Spirometry, §3.22, Tables I - II**; **Carbon Monoxide Diffusing Capacity, §3.7**, with a DLCO of less than 60%; or a very abnormal **Arterial Blood Gas Study (ABGS), Resting, §3.2 , Tables A - C**, should not be given exercise ABGS.

If a person has advanced pulmonary disease based on resting studies, decreased arterial oxygen (hypoxemia) induced by exercise would not only be predictable based on the resting studies but could be unnecessarily life- threatening. For example, hypoxemia can increase the risk of a fatal cardiac arrhythmia especially in the presence of ischemic heart disease. However, there are no absolute formulas for deciding the appropriateness of exercise ABGS; such determination ultimately must be based on the informed judgment of the physician who will perform the testing. Also, the SSA should not request such testing if there are documented contraindications to such testing.

Technique

The patient undergoes monitored exercise either on **Treadmill Stress Testing (TST, TMST), §4.51 (Chapter 4)**, or **Bicycle Ergometry/Supine Ergometry, §4.9 (Chapter 4)**, and reference should be made to the discussion of those tests as appropriate.

The patient wears either a mask or a mouthpiece and a nose-clip, so that the volume of air breathed during exercise can be determined and to be able to analyze the oxygen (O_2) and carbon dioxide (CO_2) content of exhaled air. Arterial blood gas studies (ABGS) should be done prior to exercise, and during the last 2 minutes of exercise. ABGS can be performed using an indwelling catheter in the radial artery or by using a hypodermic syringe to puncture the radial artery for samples of blood. The intensity of exercise achieved depends on a protocol adjusted to the individual patient; generally, exhaustion should be achieved in about 10 - 12 minutes.

Interpretation

Reference should be made to the discussion of **Arterial Blood Gas Study (ABGS), Resting, §3.2**.

A person with significant lung disease can have normal ABGS at rest, only to have PaO_2, $PaCO_2$, or SaO_2 fall with various levels of exercise depending on the severity of the underlying pulmonary impairment; as the body is exercised more oxygen is demanded than the lungs can supply. Resting ABGS, oxygen consumption,

[1] Dyspnea is shortness of breath (SOB).

carbon dioxide production, etc., are compared to values obtained at various levels of exercise.

Care should be taken not to confuse arterial gas pressures (PaO_2, $PaCO_2$; the small "a" means "arterial") with atmospheric gas pressures (PO_2, PCO_2) such as those in exhaled air or produced by medical equipment, etc. Some medical studies, as well as physician and hospital medical records may not make this distinction in nomenclature and should be reviewed with that fact in mind.

Normally, there should be no desaturation (fall in SaO_2) with exercise. Normal values for oxygen consumption (VO_2) are compatible with a normal study. Carbon dioxide (CO_2) production may also be measured. If the patient makes good effort, and cannot achieve a VO_2 more than 17.5 ml O_2/kg body weight/min (5 METs)[2] there is severe functional limitation based on pulmonary disease when accompanied by a corresponding abnormality in ABGS (see below).

ABGS must be interpreted in terms of the altitude above sea level at which the test is performed since normal values are lower at higher altitudes. Tables A, B, and C in **Arterial Blood Gas Study (ABGS), Resting, §3.2**, are of value in interpreting the effect of exercise on arterial blood gases.[3] If the values of $PaCO_2$ and PaO_2 in these tables occur at rest[4] or at an exercise level no higher than 5 METS, they are sufficiently abnormal that the patient will be confined to a chair or bed most of the time by inability to obtain sufficient oxygenation for any significant physical activity. ABGS values falling as low as those in Tables A, B, or C at exercise levels *higher* than 5 METs suggests that an individual cannot safely maintain exertion at that level of exercise and physical activity must remain below that level. For example, if the patient manages to reach 7 METS of exertion before his PaO_2 falls and he becomes too short of breath to continue exercise, then his activities must always be restricted to lower levels of exertion than 7 METs. Therefore, the exercise level and to what degree the ABGS and other measured factors (e.g., oxygen consumption, carbon dioxide production) become abnormal affects the interpretation of the result.

Normally, the ratio of the *dead space* to the *tidal volume* (V_D/V_T) should decrease with increasing levels of exercise. The dead space is the volume of air breathed that does not come in contact with the lungs, i.e., the space in the nasopharynx, trachea, and bronchi. The tidal volume is the volume of air ventilated during one cycle of respiration (inhaled and exhaled). If the V_D/V_T remains the same or increases, pulmonary vascular disease[5] may be present.

Malingering is possible in this type of testing and can make interpretation more difficult. For example, intentional rapid breathing will produce falsely low values for oxygen consumption and also workload (exercise level) achieved. This circumstance would be suggested by PCO_2 levels less than 35 mm Hg in the last part of a breath of exhaled air (end-tidal volume): excessively rapid breathing with normal lungs (malingering) is hyperventilation that will excessively blow off carbon dioxide, resulting in lower exhaled concentrations of that gas.

Comments

Since the patient is undergoing stress testing with monitoring of EKG, vital signs, symptoms, and overall clinical condition, other abnormalities such as evidence of ischemic heart disease or peripheral vascular disease may be found during testing although not the primary purpose of exercise ABGS.

Some protocols for exercise ABGS may indirectly measure oxygen saturation of hemoglobin (SaO_2) using **Pulse Oximetry, §3.21**, rather than using the invasive and somewhat painful procedure of arterial puncture or an indwelling arterial catheter to directly measure arterial blood gases. A decline in oxygen saturation of greater than 5% with exercise is considered abnormal.

Cardiac transplant patients have had the nerves to their original heart cut when they received the

[2] One MET is one metabolic equivalent and is an oxygen consumption of 3.5 ml/kg body weight/minute.

[3] Tables A, B, and C are adapted from the Social Security Administration's Listing of Impairments, Code of Federal Regulations, Title 20, Part 404, Subpart P, Appendix 1 (2001).

[4] Resting ABGS satisfying these tables should be considered a contraindication to exercise testing.

[5] Pulmonary vascular disease, also called pulmonary vascular obstructive disease (PVOD), refers to disease of the arterial system of the lungs.

transplanted heart, and the nerves of the transplanted heart cannot be re-connected to the recipient's nerves. Because the transplanted heart is denervated, more time is required for it to adjust to changing workloads imposed by different exercise levels. For this reason, such patients should be given at least 3 minutes to adjust to a particular level of exercise before going to the next, higher level.

If the FEV_1 is measured by spirometry post-exercise and falls by at least 20% from pre-exercise levels, then exercise-induced asthma may be present. The post-exercise spirometry should be done within 30 minutes after stopping exercise if this assessment is to be made, since severity peaks at about 5 - 10 minutes after exercise. The SSA does not purchase exercise ABGS for the purpose of evaluating the possibility of exercise-induced asthma, and SSA listings dealing with asthma make no provision for exercise ABGS. However, information related to exercise-induced asthma might become available to the SSA from a treating physician. More than 90% of asthmatics will experience worsening after exercise that is proportionate the intensity of the exercise. There are rare individuals who are not asthmatic except with exercise. The importance of asthma in exercise ABGS is that it represents a potential risk factor in exercise testing for which the testing physician should be prepared.

§3.2 Arterial Blood Gas Study (ABGS), Restin

Relevant Social Security Medical Listings

- Listing 3.02 Chronic Pulmonary Insufficiency (Adults)
- Listing 103.02 Chronic Pulmonary Insufficiency (Children)
- Listing 3.06 Pneumoconiosis (Adults)

Type

Objective/Physiological Test (Pulmonary)

Can SSA Purchase?

Yes. However, this test should be ordered by the SSA only if all other methods of possible allowance of a disability claim have been eliminated.

Purpose

- Measure oxygen (O_2) and carbon dioxide (CO_2) gases in arterial blood.
- Evaluate the acidity/alkalinity of arterial blood.

Technique

A hypodermic syringe is used to obtain a sample of arterial blood. Usually blood is taken from the radial artery in the wrist, but the sample could be drawn from any artery as appropriate for the circumstances. The sample must be kept cold by immediately placing it on ice, and analyzed within 1 hour maximum.

Interpretation

Arterial Blood Gas Study (ABGS)

An arterial blood gas study (ABGS) provides important information about the lungs ability to perform the vital function of gas exchange, i.e., the elimination of waste carbon dioxide from the blood into the air and absorption of oxygen into the blood from the air.

PaO_2 represents the arterial oxygen pressure, and $PaCO_2$ represents the arterial carbon dioxide pressure. The pH represents the arterial acidity/alkalinity. SaO_2 is the percent saturation of hemoglobin with oxygen. Normal values at sea level[6] without supplemental oxygen are PaO_2 80 - 100 mm Hg[7], $PaCO_2$ 35 - 45 mm Hg, pH 7.35 - 7.45, and SaO_2 95 - 99%. Arterial blood bicarbonate (HCO_3) is frequently reported on ABGS and is normally 21 - 28 meq/L.[8] Bicarbonate is important in buffering the blood,

[6] Normal PaO_2 decreases with altitude, and care should be taken to refer to the particular laboratory's reference ranges for "normal" values. Additionally, elderly individuals may have a lower normal PaO_2. For a person over 70, 80 and 90 years of age respectively, a resting PaO_2 of greater than 70, 60, and 50 mm Hg may be considered normal.

[7] Normal PaO_2 is 60 -70 mm Hg in the newborn.

[8] Sometimes reported as millimole (mmol)/L, but the numbers would be the same.