Blood Doping

Background

1. Definition:
   - "Blood doping" or "blood boosting" originally:
     - Transfusion of blood that had been withdrawn and stored (autologous)
     - Transfusion of another's blood (allogenic or heterologous)
       - To increase athlete's RBC count
   - Currently other technology exists to incr RBC count and capacity to carry and deliver oxygen
     - Recombinant human erythropoietin (rhEPO)
     - Other forms of artificial EPO
     - Artificial blood substitutes
       - Modified hemoglobin solutions
       - Perfluorocarbon-based emulsions
     - Novel erythropoiesis-stimulating protein (darbepoetin /Aranesp®)
     - Gene-activated erythropoietin (Dynepo®)
     - Encapsulated recombinant human erythropoietin
     - Gene therapy for alteration of endogenous erythropoietin production
     - Erythropoietin mimetics
     - Haematopoietic cell phosphatase inhibitors

2. Not considered blood doping:
   - Altitude training
   - Altitude tents
   - High altitude (nitrogen) house

3. General information
   - VO2max = max oxygen uptake
     - Major determinant of performance in endurance events
     - Affected by
       - Pulmonary respiratory fnx
       - Diffusion capacity of lung
       - Oxygen transport capacity
         - Fxn of hemoglobin concentration and cardiac output
       - Tissue ability to absorb and utilize delivered oxygen
   - Training protocols for endurance athletes often aim to improve VO2max
     - Legal
       - Exercise at low altitude, live at higher altitude ("live high-train low")
       - Exercising and living at high altitude ("live high-train high")
       - Altitude tents, altitude (nitrogen) houses, supplemental oxygen delivery
     - Illegal
       - Recombinant human erythropoietin (rhEPO)
       - Other forms of artificial EPO
       - Artificial blood substitutes
       - Autologous or heterologous blood transfusion
Performance improvement from blood transfusion may be small but significant in elite competition

- Study in two sets of cross-country skiers
  - Group that received autologous blood transfusion performed 5.3% better immediately after transfusion & 3.1% better 14 days after transfusion vs control group

**Pathophysiology**

1. Incidence/prevalence
   - Unknown how commonly this is used in sports
2. Risk factors
   - More benefit for endurance athletes
3. Morbidity/mortality
   - Autologous blood transfusion
     - Large quantity transfusions associated with hypercalcemia and coagulopathy
       - Due to citrate preservative used in blood storage
   - Allogenic/Heterologous blood transfusion
     - Hypercalcemia and coagulopathy if blood is stored in preservative prior to infusion
     - HIV, Hepatitis B, and Hepatitis C transmission is possible
     - Transfusion reactions
       - Mild fever and hives
       - Severe hemolysis and DIC
   - Recombinant Human Erythropoietin
     - Numerous risks, see prescribing info
       - Hyperviscosity
       - Thrombosis
       - HTN
       - Post-tx blunted endogenous erythropoietic response with secondary anemia
       - Development of anti-EPO antibodies
       - Pure red cell aplasia
   - Modified hemoglobin solns exist, complications include:
     - Increased pulmonary and peripheral arterial pressures
     - GI symptoms: pylorospasm, pancreatitis
     - Solutions from human or animal hemoglobin can contain and transmit infective agents or induce antibodies
     - Renal cell necrosis
   - Perfluorocarbon-based emulsions
     - Chemically inert and highly soluble chemicals that increase blood solubility of gases, incl oxygen
     - Perfluorocarbon is exhaled through lung and can be measured with chromatography, complications include:
       - Myalgia and fever
       - Thrombocytopenia
       - Some forms produced with egg, can induce allergic reaction
       - Phagocytosis can lead to engorgement of hepatic system by:
         - Microclots
Blood Doping

- Inhibition of white blood cells
- Complement activation
- Immune system disturbance
- EPO gene therapy
  - Early studies have demonstrated difficulties in regulating rate of EPO production

**Diagnostics**

1. History
   - No specific symptoms
   - May see improved performance
   - Hyperviscosity symptoms
     - Fatigue
     - Headaches
     - Malaise

2. Physical exam
   - No physical changes usually noted

3. Diagnostic testing
   - Continuing to evolve
   - Appropriate testing depends on doping method
   - Screening hematocrit used to determine athletes with "at risk" level
     - Hematocrit >50%
   - DNA testing, spectrometry, other methods in development

- Guidelines and recommendations
  - International Olympic Committee (IOC)
  - National Collegiate Athletic Association (NCAA)
  - World Anti-Doping Agency (WADA)
  - United States Anti-Doping Agency (USADA)

**Differential Diagnosis**

1. Polycythemia Rubra Vera
2. Severe dehydration

**Therapeutics**

1. If doping is suspected and pt has hyperviscosity symptoms
   - Phlebotomy is indicated

2. Discourage use of blood doping

3. Follow-Up
   - Follow-up should be based on individual pts symptoms and MDs request

**References**


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