Systemic dysfunction in Eisenmenger physiology

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Eisenmenger Physiology

- Irreversible pulmonary vascular obstructive disease
- R-L shunt
- Chronic cyanosis

→ A complex multisystem disorder

Eisenmenger Physiology

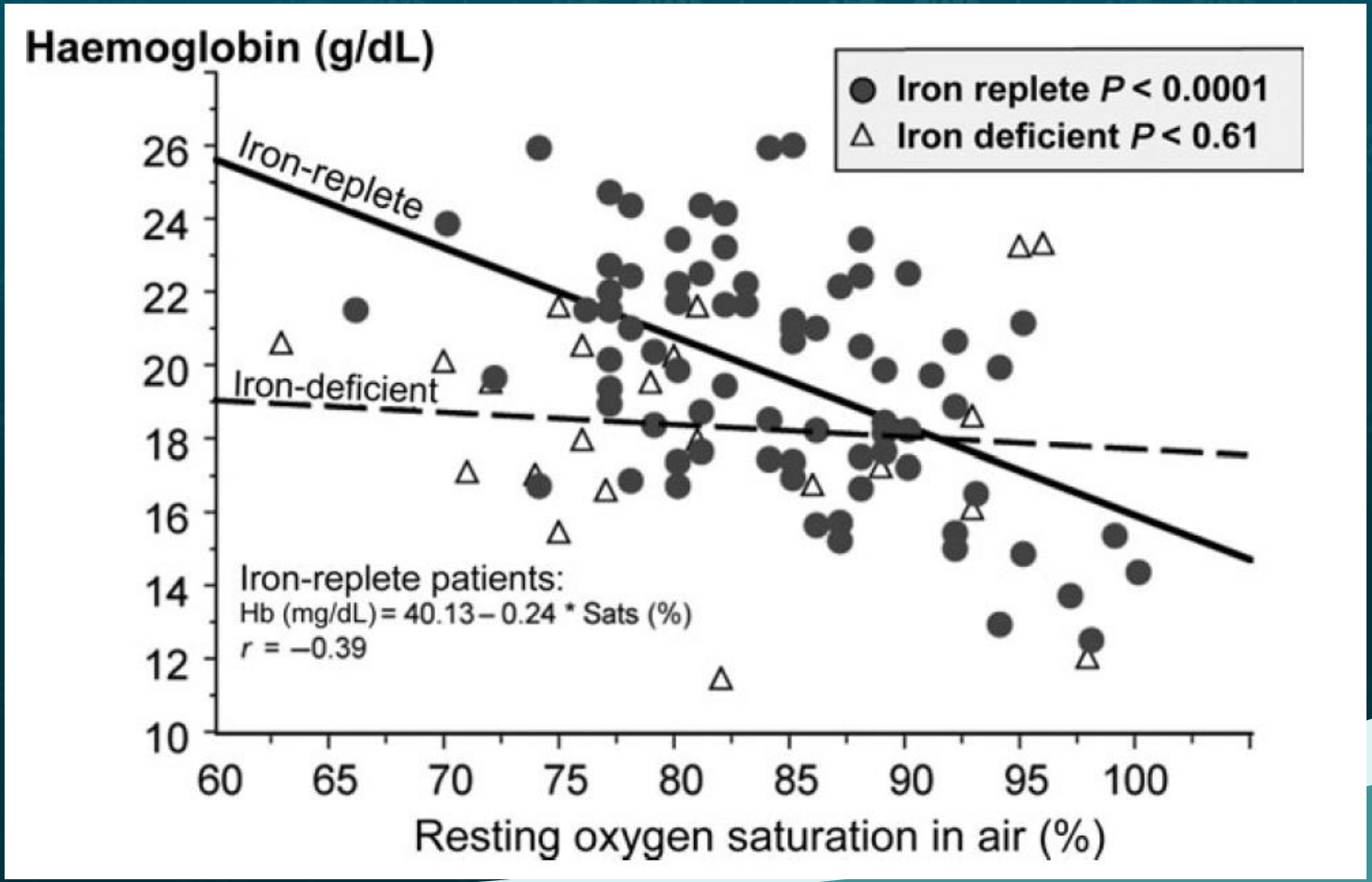
- "A complex multisystem disorder"
  - Erythrocytosis and hyperviscosity syndrome
  - Iron deficiency
  - Neurological complicaions
  - Hemostasis
  - Renal dysfunction
  - Metabolic problem
  - Systemic and coronary circulation
  - Orthopedic problems
  - Pregnancy issue
  - Endocarditis

Erythrocytosis

- Increased RBC production (↑ erythropoietin)
- Physiologic response to tissue hypoxemia to improve O_2 carrying capacity
- Increase in RBC mass and whole-blood viscosity
- Whole-blood viscosity –"Hyperviscosity syndrome"
  - RBC mass and morphology
  - Plasma viscosity
- Not associated with cerebral arterial thrombosis

(Perloff et al. Circulatin 1993;87;1954)

Erythrocytosis



Eur Heart J 2006;27: 1737-42

Erythrocytosis

- Hyperviscosity syndrome
  - Headache, dizziness, loss of concentration
  - Visual disturbance, tinnitus
  - Myalgias, muscle weakness, and fatigue
  - Restless legs
- DDx
  - Volume depletion
  - Iron deficiency
  - Decreased systemic O_2 delivery

Erythrocytosis

- Phlebotomy
  - To relieve moderate to severe hyperviscosity symptoms, when Hct > 65% and Hb >20g/dl, in the absence of dehydration and iron deficiency [2008 ACC/AHA guideline]
  - To improve hemostasis or for autologous blood donation before surgery
  - 250-500 ml over 30-40 min with infusion of N/S, 5% dextrose, or Hartmann
  - Common cause of iron deficiency and CVA

Iron deficiency

- Nasal bleeding, Hemoptysis, Menorrhagia
- Frequent phlebotomy
- Iron deficiency anemia
  - Decreased oxygen carrying and exercise capacity
  - Increased risk of stroke - microcytic anemia
  - Hyperviscosity-like symptom, HCT < 65%
  - Iron supplementation for a short period (7-10 days)
    - When? MCV < 82
      serum ferritin ≤15 μg/L
      transferrin saturation ≤ 15%
    - Should avoid excessive erythrocytosis
      - Already increased erythropoietin

Hemostasis

- Increased risk of bleeding
  - Pulmonary hemorrhage – life threatening
  - Menorrhagia
- Hemostatic abnormalities
  - Deficient coagulation factor (II, V, VII, IX, X, von Willebrand factor)
  - Abnormal platelet count and function
  - Dilatation and increased density of systemic arteriole
  - Noncardiac surgery – prophylactic phlebotomy, if HCT > 65%

Hemostasis

- Increased risk of thrombosis
  - Large dilated vessel and slow flow, esp, PA system
  - Prosthetic material
  - Hemastatic defect does not protect against thrombotic complication
- Anticoagulation- Weigh the Risk vs. benefit
  - Atrial fibrillation
  - Recurrent thromboembolic events
  - Deep vein thrombosis (DVT)
  - Intracardiac device such as pacemaker

CNS complications

- Cerebrovascular events
  - Reported up to 14%
  - Irrespective of hematocrit level
  - Microcytosis caused by iron deficiency
  - Atrial fibrillation, arterial hypertension (
  - Paradoxical embolism - IV line, DVT
  - Volume, Iron, air filter
- CNS bleeding
  - Usually associated with anticoagulation
- Cerebral abscess
  - Headache – may be misinterpreted as a hyperviscosity symptom

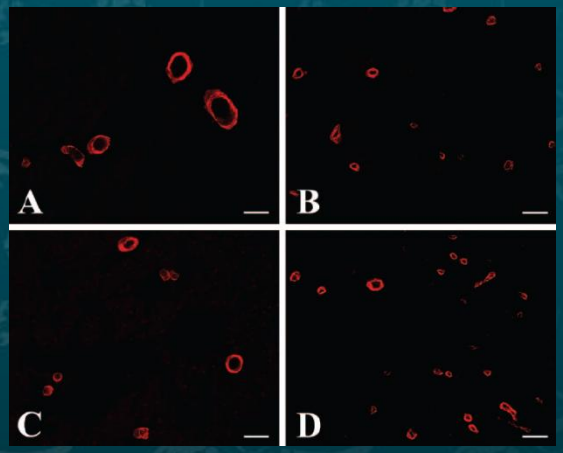
Systemic vessel

- Arterioles - increased tissue density and dilatation
  - Hemostasis
  - Syncope
  - Also in the coronary system and renal glomerulus
- Systemic endothelial dysfunction
  - Reduced endothelial vasodilation to Ach
  - Reduced basal bioavailability of NO
  - May contribute to the increased risk for CNS ischemic complications

Coronary circulation

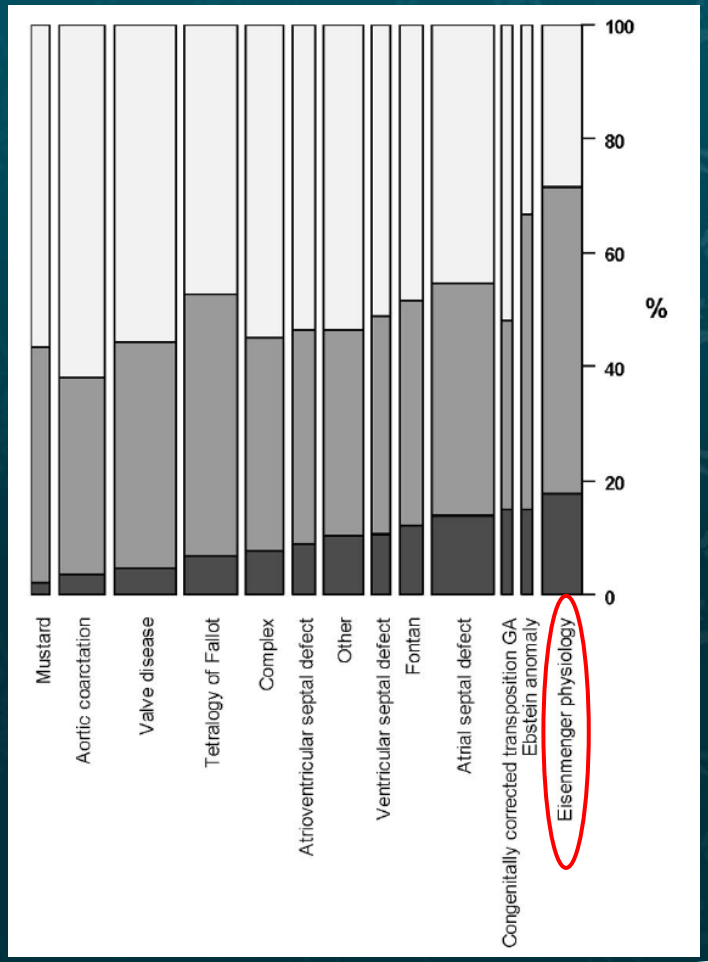
- Dilated coronary arteriols

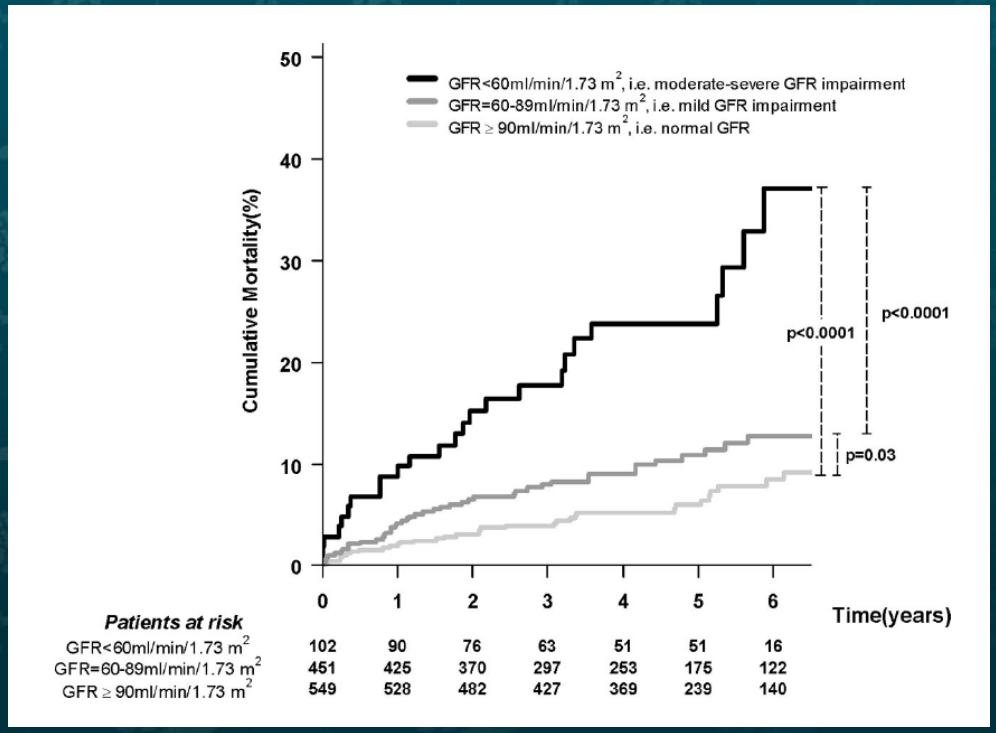
  Circulation 2006;114:196-200



- Chest pain
  - Hypoxemia or subendocardial ischemia
  - Epicardial coronary artery compression by dilated MPA
  - Coronary artery lesions

Renal function





Decreased GFR and Outcome

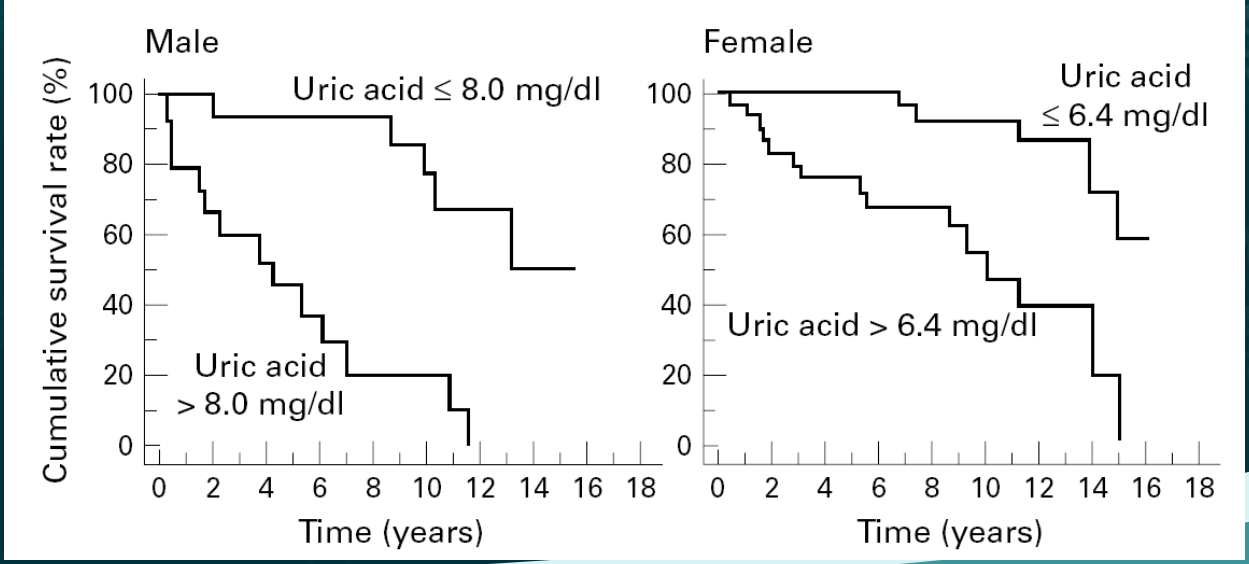
Circulation. 2008;117:2320-2328.)

Renal function

- Proteinuria
  - Increased hydraulic pressure
  - Phlebotomy, ACI?
- Hyperuricemia – increased resorption
  - Usually asymptomatic
  - Gout, renal stone, nephropathy - rare
  - allopurinol, colchicine, if symptom
  - No or cautious use of diuretics, NSAID, ACI
- Radiopaque media – check GFR before
- Avoid dehydration

Hyperuricemia

- Increased resorption or decreased secretion
- Overproduction secondary to tissue hypoxia
- Reflect organ injury induced by impaired oxidative metabolism
- Correlate with a poor outcome



Heart 2000;84:53-8

Orthopedic problems

- Hypertrophic osteoarthropathy
  - bone pain, arthralgia
  - megakaryocyte to systemic circulation → release growth factors
  - Salsalate
- Clubing
- Scoliosis

Gall stone

- Increased RBC (heme) turn over
- Pigment gall stone (Calcium bilirubinate)
- Acute cholecystitis, can be complicated by sepsis or infective endocarditis

Pregnancy

- Contraindication
  - maternal mortality – 30-50%
    - syncope, thromboembolism, hypovolemia, hemoptysis or preeclampsia
  - Fetal issues
    - spot. abortion; 20-40%
    - prematurity; 50%
    - IUGR; 20-30%
    - CHD recurrence ; around 5%
- Early termination
- Contraception
- Delivery; planned vaginal delivery

Air flight or high altitude

- do not need to be advised against air travels
- adequate hydration
- avoid caffeine and alcohol
- supplemental oxygen
- prevention of DVT

FU

- At least every year
  - Functional capacity, 6-min walk test
  - CBC – HB, HCT, PLT, RBC profile
  - Chemistry – uric acid, BUN, Cr, Electrolyte
  - Iron study - ferritin, transferrin, transferrin saturation;
- Infection
  - Annual flu shot
  - Pneumococcal vaccine every 5 yrs
  - Endocarditis prophylaxis

FU

- Avoid volume depletion
- Avoid iron deficiency (no routine phlebotomies)
- No smoking and recreational drug use
- Precaution or avoidance of drugs that impair renal function
- Use of an air filter for all intravenous lines
- Prompt therapy of respiratory tract infections
- Avoidance of strenuous exercise/ stress (traveling)

감사합니다