Blood management in surgery - understanding haemoglobin

Tim Watts
Laboratory manager
Blood Sciences
NDDH
NDDH laboratory coverage

- Population of area covered: 170000.
Interesting facts

• A person of average height and weight will have approximately 4.6 litres of blood.
• Blood accounts for about 8% of body weight.
• Approx 2 million red blood cells are made and destroyed each second.
Haematopoiesis

All blood cells are produced from a common precursor cell, in the bone marrow. (haematopoietic stem cell)

Acute leukaemia is an abnormal proliferation of blast cells.
Haemoglobin

- Carries oxygen to all tissues
- Contained within red cells
- Fairly important!
- Accurate measurement vital
  - pre-anaesthesia
  - general health
  - blood loss/trauma/surgery

Lack (anaemia) is commonest blood disorder
What is anaemia?

- An – lack of
- Aemia – in the blood
- We define anaemia as:
  - A suboptimal Oxygen carrying capacity
• **Some causes of Anaemia:**
  - iron deficiency
  - vitamin B12/folate deficiency
  - malabsorption
  - bleeding/trauma/surgery
  - pregnancy
  - renal failure
  - mechanical or autoimmune cell damage (haemolysis)
  - secondary to other illnesses, e.g. leukaemia, cancer, rheumatoid
  - and their treatments (myelosuppression)
• Normal red cells
The Full Blood Count

- Red blood cell parameters:
  - **MCV** - mean (red) cell volume - fL
  - **MCH** - mean (red) cell haemoglobin - g/dL
  - **RDW** - red (cell) distribution width - %
  - **HCT** - haematocrit
  - **RBC** - red cell count - 10^12/L
Iron deficiency

• The most common type of anaemia worldwide
• Haemoglobin is not produced
• RBCs are plentiful but small and contain reduced amount of haemoglobin
• So - RBC normal/low, MCV/MCH low
• RDW usually normal/high
Iron deficiency

• A fine balance – gain and loss
Iron deficiency

- **Caused by:**
  - Excess chronic blood loss, e.g. menstruation
  - Dietary deficiency/malabsorption
  - Functional deficiency - the iron is there but cannot be used. Anaemia of chronic disorders.
  - Common in children due to muscle growth
IRON DEFICIENCY

Treatment IRON oral or IV - not transfusion
Iron deficiency

• Iron deficient red cells  vs. normal
Iron deficiency

- Treatment will give a rapid response
- Hb, MCV and MCH will rise
- RDW will increase dramatically
- Treat over 3 months to build stores
Iron deficiency

Dimorphic red cells [Iron deficiency anaemia]
Dimorfinen punasolulöydös [Raudanpuutosanemia]
Vitamin B12/folic acid deficiency

- More common in the elderly
- Severe form (Pernicious anaemia) results from lack of gastric intrinsic factor - either autoimmune (65%) or other stomach problem
- Also caused by diet (vegans) or malabsorption (Crohn’s, coeliac)
Vitamin B12/folic acid deficiency

• Very few, very large red cells due to delayed nuclear maturation in marrow
• Hb drops very low, (<3.0 g/dl) until no longer compatible with life (hence the term Pernicious)
• MCV high, RBC low
• RDW high
Vitamin B12/folic acid deficiency

• Very few, very large red cells

• Note the neutrophil!
Vitamin B12/folic acid deficiency - P.A.

- Pernicious anaemia was treated by eating raw liver as this is very rich in vitamin B12 and passive absorption sufficient
- The more wealthy soaked it in Port first!
- Now B12 is given intramuscularly
- No need for I.F.
PERNICIOUS ANAEMIA -VITAMIN B12 DEFICIENCY

LOW HAE摩GLOBIN
RAISED MCV
LOW VITAMIN B12 - FAILURE TO ABSORB
OTHER AUTO- IMMUNE DISORDERS

Treatment Vitamin B12 - not transfusion
Anaemia of Renal failure

• The bone marrow is stimulated to produce red cells by a hormone called ERYTHROPOEITIN (EPO)
• This is made by the kidney and is lacking in renal failure so the marrow produces minimal cells
• Treated by giving recombinant EPO
• Some athletes cheat by giving themselves EPO
Anaemia of Pregnancy

• Usually caused by haemodilution during 3rd trimester - increasing plasma volume
• Expectant mums also prone to iron and folate deficiency due to demands of growing foetus
Use of RBC indices

- **MCV** - low in iron deficiency, some thalassaemias
- High in B12/folate deficiency, liver disease, some thyroid disorders
- **RDW** - normal if all RBCs the same size
- Increased if there is a significant variation within a patient
Haemolytic anaemia

- Caused by red cell destruction either by mechanical damage or by autoimmune process (antibody coating, incompatible blood Tx)
- Spleen removes broken/coated cells
- Causes marrow to increase cell production by as much as 8x
Haemolytic anaemia

- Blood film appearance
Haemolytic anaemia

- Causes of mechanical RBC destruction
  - old-type artificial heart valves
  - burns
  - microangiopathic disease
  - malaria
  - sickle cell disease
  - other Hbopathy
Haemolytic anaemia

• Blood film appearance - RBC damage
Reticulocytes

- Juvenile red cells containing nuclear remnants
- *Can be counted by staining or flow cytometry*
- Indicator of bone marrow activity
- Normal range 0.02 - 0.2% of red cells
- Raised post bleed, post haematinic therapy and in haemolytic anaemias
Sickle cell anaemia

- Caused by a single amino acid substitution - Hb S
- Irreversibly crystallises in reduced $O_2$ levels
- Deforms red cell, hence 'Sickle'
- Cells cannot pass oxygen or move through capillaries - pain, hypoxia, death
- Confers protection against malaria
- Treated with transfusion and $O_2$
Sickle cell anaemia

• Sickled red cells - electron microscope
Sickle cell anaemia

- Sickled red cells - light microscope
Thalassaemia

From thalassa - sea
Sometimes known as Mediterranean anaemia
- Alpha - mainly Chinese, far eastern
- Beta - mainly Greek, Cypriot
- According to Hb absent globin chains
- Homozygotes - alpha do not survive
  - Beta transfusion dependant
- Heterozygotes (trait)
  - Normal/lowish Hb
  - Low MCV
  - However NOT iron deficient so don’t treat
  - Raised RBC
  - Elevated Hb A2 A2/F or Hb H in Alpha