A Detailed Study Of Five Stages Of Iron Deficiency In Patients With Severe Anaemia Due To Hookworm Infection

Govindarajalu Ganesan
Associate professor.
Dept. of General surgery Indira Gandhi Medical College and Research Institute
Puducherry.-605009
Email id: drgganesan@gmail.com

Abstract:
Objective: A detailed study of 5 stages of iron deficiency was done in patients with severe anaemia due to hookworm infection.
Methods: A study of 1307 patients who had undergone upper gastro-intestinal endoscopy for a period of 5 years and one month from May 2009 to May 2014 was carried out. In all the patients found to have hookworms in duodenum, investigations were done to know about the presence of anaemia. In patients with severe anaemia, peripheral smear examination was also done in addition to haemoglobin estimation. But in one patient with severe anaemia, serum ferritin, transferrin saturation, serum iron, mean corpuscular volume or MCV, mean corpuscular haemoglobin or MCH were also done in addition to haemoglobin estimation and peripheral smear examination. Symptoms and signs of the patient were also noted. The results were found as given below.
Results: In one patient with severe anaemia due to hookworm infection, serum ferritin which indicate first stage of iron deficiency, transferrin saturation and serum iron which indicate second stage, haemoglobin estimation which indicate third stage, mean corpuscular volume or MCV and mean corpuscular haemoglobin or MCH which indicate fourth stage of iron deficiency were all found to be very low. The peripheral smear of the patient showed severe microcytic hypochromic anaemia which also indicate fourth stage of iron deficiency. The patient also had symptoms and signs of iron deficiency such as shortness of breath, weakness, dizziness, and pallor which indicate fifth or very late stage of iron deficiency.
Conclusion: Hence estimation of serum ferritin, transferrin saturation, serum iron, haemoglobin, mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) and symptoms and signs of iron deficiency indicate the various stages of iron deficiency in patients with severe anaemia due to hookworm infection.

Keywords: serum ferritin, transferrin saturation, serum iron, haemoglobin estimation, mean corpuscular volume, mean corpuscular haemoglobin.

Introduction:
Many studies have also shown the presence of severe anaemia in severe hookworm infection (1 to 17). But so far detailed study of the 5 stages of iron deficiency was not done in patients with severe anaemia due to hookworm infection. Hence a detailed study of the 5 stages of iron deficiency
in patients with severe anaemia due to hookworm infection was done.

Materials and Methods:

This study was conducted in the department of general surgery, Aarupadai Veedu Medical College And Hospital, Puducherry. A study of 1307 patients who had under gone upper gastrointestinal endoscopy for a period of 5years and one month from May 2009 to May 2014 was carried out. In all the patients found to have hookworms in duodenum, investigations were done to know about the presence of anaemia. Anaemia is defined as haemoglobin < 12g/dl or 12g% in women and haemoglobin < 13 g/dl or 13g% in men. Severe anaemia is taken as haemoglobin < 7g/dl or g%. In patients with severe anaemia, peripheral smear examination was also done in addition to haemoglobin estimation. But in one patient with severe anaemia, serum ferritin, transferrin saturation, serum iron, mean corpuscular volume or MCV, mean corpuscular haemoglobin or MCH and peripheral smear examination were also done in addition to haemoglobin estimation. Symptoms and signs of the patient which indicate fifth stage of iron deficiency were also noted. The results were found as given below.

Results:

Out of these 1307 patients, 14 patients found to have hookworms in duodenum were taken into consideration for our study. Out of these 14 patients with hook worm infection, 2 patients were found to have severe anaemia. In one patient with severe anaemia, serum ferritin which indicate first stage of iron deficiency, transferrin saturation and serum iron which indicate second stage, haemoglobin estimation which indicate third stage, mean corpuscular volume or MCV, mean corpuscular haemoglobin or MCH and peripheral smear examination which indicate fourth stage of iron deficiency were also done. Symptoms and signs of the patient which indicate fifth stage of iron deficiency were also noted. The results were found as given below.

Serum ferritin or stored iron [decreased in stage 1 of iron deficiency]

Stage 1 of iron deficiency is characterized by decreased iron stores and serum ferritin level falls to < 20 ng/mL. In our patient also, serum ferritin is very low-1.4 ng/mL indicating exhausted iron stores.

Percent transferrin saturation and serum iron [decreased in stage 2 of iron deficiency]

During stage 2 of iron deficiency, erythropoiesis is impaired. Erythropoiesis is impaired when transferrin saturation falls to < 16% and serum iron falls to < 50 μg/dL (18). In our patient, transferrin saturation is very low and is only 5% and serum iron is very low-20 μg/dL indicating severely impaired erythropoiesis. Other studies have also shown very low level of serum iron in patients with severe anaemia due to hookworm infection diagnosed by doing endoscopy (1, 3, 4, 5). One study has also shown that decreased serum transferrin saturation (transferrin saturation < 16%) implies an inadequate supply of iron to the marrow in patients with iron deficiency anemia (19).

Stage 3 of iron deficiency [iron deficient anemia with decrease in haemoglobin]

During stage 3 of iron deficiency, anemia or reduction in haemoglobin with normal-appearing red blood cells and indices develops. Hookworm infection causes blood loss which results in iron deficiency anemia. In our patient also with severe hookworm infection haemoglobin is very low-3.2 g% [normal range 12-16 g%]. Severe anaemia (haemoglobin < 7 g/dl or g%) is reported to occur in patients with severe anaemia due to hookworm infection diagnosed by doing endoscopy in many studies (1 to 17).

Stage 4 of iron deficiency [Microcytosis and hypochromia]
Our patient had also undergone peripheral smear examination which showed severe microcytic anaemia and severe hypochromic anaemia.

**Microcytosis or low mean red cell volume**

In our patient, mean red cell volume or MCV is very low and is only 50.7 femolitres or fl (normal range 82-92 fl). Other studies have also shown that the mean corpuscular volume (MCV) is lower [microcytic] in patients with severe anaemia due to hookworm infection diagnosed by doing endoscopy (1 to 6).

**Hypochromia or low mean corpuscular haemoglobin**

Mean corpuscular haemoglobin or MCH was also very low 15 picograms or pg (normal range 27-32 pg) in our patient. Studies have also shown that the mean corpuscular hemoglobin (MCH) is lower [hypochromia] in patients with severe anaemia due to hookworm infection diagnosed by doing endoscopy (1, 2).

**Symptoms and signs of iron deficiency [occur in stage 5 of iron deficiency]**

Our patient also had symptoms and signs of iron deficiency such as shortness of breath, weakness, dizziness, and pallor which indicate fifth or very late stage of iron deficiency. One study has also shown the occurrence of weakness or fatigue and shortness of breath in a patient with severe anaemia due to hookworm infection diagnosed by doing endoscopy (11).

**Discussion:**

Iron deficiency is the most common micronutrient deficiency in the world. It can affect all populations and age groups, but the most vulnerable groups are women and children (18). Hookworm infection is the most common cause of iron deficiency in developing nations.

**Iron deficiency**

Iron deficiency develops in stages.

**Early stage and late stage of iron deficiency**

In the early stage, iron requirement exceeds intake, causing progressive depletion of bone marrow iron stores indicated by decreased serum ferritin level.

During later stages, iron deficiency impairs red blood cells synthesis, ultimately causing anaemia indicated by decreased haemoglobin.

**Introduction about the various stages of iron deficiency.**

The first stage (iron depletion) is characterized by the absence of measurable iron stores indicated by decreased serum ferritin level.

The second stage (iron deficient erythropoiesis) is characterized by evidence of a restricted iron supply indicated by decreased transferrin saturation and serum iron in the absence of anaemia.

The third stage (iron deficiency anaemia) is characterized by a haemoglobin concentration that falls below the normal threshold for age and sex.

Stage 4 of iron deficiency (microcytosis and hypochromia) is characterized by low mean corpuscular volume and low mean corpuscular haemoglobin.

Stage 5 of iron deficiency is characterized by the presence of symptoms and signs of iron deficiency.

**Detailed discussion about the five stages of iron deficiency.**

**Stage 1 of iron deficiency (iron depletion with decrease in serum ferritin)**

Stage 1 of iron deficiency is characterized by decreased bone marrow iron stores and decreased serum ferritin level, but serum iron and haemoglobin remain normal. Stage 1 is “iron depletion”, at which there is an isolated decrease in serum ferritin levels (20). Serum ferritin concentration is a reliable index of iron stores (1...
ng/mL of serum ferritin indicates about 8 mg of storage iron. Serum ferritin does not exhibit diurnal variations as are seen with serum iron levels. Thus serum ferritin level is decreased in all stages of iron deficiency and may be the first indication of developing iron deficiency. Serum ferritin is generally considered the single best test to detect iron deficiency.

**Stage 2 of iron deficiency (iron deficient erythropoiesis with decrease in transferrin saturation and serum iron)**

Stage 2 is “iron deficient erythropoiesis”. (20). At this stage, the supply of iron to the erythroid marrow is inadequate, the serum ferritin level is low (10-20 µg/L), transferrin saturation is decreased (<16%) and serum iron falls to < 50 µg/dL (20).

**Stage 3 of iron deficiency (iron deficient anemia with decrease in haemoglobin)**

Stage 3 is “iron deficient anemia” (IDA), in which hemoglobin levels are subnormal(20). R Stoltzfus, emphasizes that haemoglobin concentration is the key indicator for iron deficiency anemia (IDA) surveillance(21). Hookworm infection produces iron deficiency anaemia and iron deficiency anaemia was defined by low haemoglobin (22to26). Anaemia is defined as the reduction in haemoglobin concentrations below the expected values[WHO,1972] (24).

**Stage 4 of iron deficiency [Microcytosis and hypochromia]**

During stage 4, microcytosis and hypochromia develop.

**Microcyticred blood cells or RBCs**

When the mean red cell volume or mean corpuscular volume[ MCV ] is low and is <80 femolitres or fl, the blood is said to be microcytic. Microcytic red blood cells indicate that thered blood cells are very small with small volume. In our patient, mean red cell volume or MCV is very low indicating that the red blood cells are very small with small volume and aremicrocytic.

**Hypochromia**

Mean corpuscular haemoglobin or MCH is low in hypochromic anaemia. Hypochromic red blood cells indicate that the red blood cells or RBCs have low amount of haemoglobin. Mean corpuscular haemoglobin or MCH is also very low in our patient indicating that the red blood cells or RBCs are hypochromic and have low amount of haemoglobin.

One study has also shown that the mean corpuscular volume (MCV) is lower[microcytic] and mean corpuscular hemoglobin (MCH) is lower[hypochromia] in patients with iron deficiency anemia (19,27 to 29).

**Stage 5 of iron deficiency (symptoms and signs of iron deficiency).**

During stage 5, iron deficiency affects tissues, resulting in symptoms and signs. Most symptoms of iron deficiency are due to anemia. Such symptoms include fatigue, loss of stamina, shortness of breath, weakness, dizziness, and pallor. Our patient also had symptoms and signs of iron deficiency which indicate fifth or very late stage of iron deficiency.

**Our patient was in fifth or very late stage of iron deficiency**

Our patient with severe anaemia due to hookworm infection was in fifth or in late stage of iron deficiency since serum ferritin, transferrin saturation and serum iron of the patient were extremely low in addition to very low haemoglobin, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and severe
microcytic hypochromic anaemia in peripheral smear and since the patient also had symptoms and signs of iron deficiency such as shortness of breath, weakness, dizziness, and pallor.

Conclusion:

1. Low serum ferritin indicates first stage of iron deficiency (iron depletion).

2. Low transferrin saturation and serum iron indicate second stage of iron deficiency (iron deficient erythropoiesis).

3. Low haemoglobin indicates third stage of iron deficiency (iron deficiency anaemia).

4. Low mean corpuscular volume or MCV and low mean corpuscular haemoglobin or MCH indicate fourth stage of iron deficiency (microcytosis and hypochromia).

5. Presence of symptoms and signs of iron deficiency such as shortness of breath, weakness, dizziness, and pallor indicate fifth or very late stage of iron deficiency.

6. Hence our patient with severe anaemia due to hookworm infection was in fifth or late stage of iron deficiency since serum ferritin, transferrin saturation, serum iron, haemoglobin, mean corpuscular volume (MCV) and mean corpuscular haemoglobin (MCH) were extremely low and since the patient also had symptoms and signs of iron deficiency.

Acknowledgement:

The author sincerely thanks the staff nurses A.K. Selvi and Nithya for their immense help rendered to the author while conducting this work. The author acknowledges the immense help received from the scholars whose articles are cited and included in references of this manuscript. The author is also grateful to authors/editors/publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed.

References:


Ancylostomaduodenale (hookworm) and Anisakissimplex. Endoscopy 2009;41(Suppl. 2):E189


26. R M Hopkins, M S Gracey, R P Hobbs, R M Spargo, M Yates, R C Thompson The prevalence of hookworm infection, iron deficiency and anaemia in an aboriginal community in north-
west Australia Med J Aust. 1997 Mar 3;166 (5):241-4

