SERUM IRON AS AN IMPORTANT INDICATOR OF IRON DEFICIENCY ANEMIA IN SEVERE HOOKWORM INFECTION DIAGNOSED BY DOING ENDOSCOPY

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ABSTRACT

Objective: Serum iron as an important indicator of iron deficiency anemia in severe hookworm infection diagnosed by doing endoscopy is studied. Methods: A study of 1100 patients who had undergone upper gastrointestinal endoscopy for a period of four and half years from May 2009 to October 2013 was carried out. All the patients found to have hookworms in duodenum, investigations were done to know about the presence of severe anaemia. In patients with severe anaemia[haemoglobin <7g/dl or g%] peripheral smear examination was also done in addition to haemoglobin estimation. But in one patient with severe anaemia, in addition to haemoglobin estimation and peripheral smear examination which indicate iron deficiency anaemia, serum iron is also done. The results were found as given below. Results: Out of these 1100 patients, 14 patients found to have hookworm infections in duodenum were taken into consideration for our study. Out of these 14 patients, 2 patients were found to have severe anaemia[haemoglobin <7g/dl or g%] due to severe hookworm infection. The peripheral smear of both the patients showed severe hypochromic anaemia. In one patient with severe anaemia, in addition to low haemoglobin and microcytic hypochromic RBCs in peripheral smear examination which indicate iron deficiency anaemia, serum iron is also found to be very low. Conclusion: Hence in addition to low haemoglobin and microcytic hypochromic RBCs in peripheral smear examination which indicate iron deficiency anaemia, low serum iron is also as an important indicator of iron deficiency anaemia in severe hookworm infection diagnosed by doing endoscopy.

KEYWORDS: low hemoglobin, microcytic hypochromic RBCs, peripheral smear examination, low serum iron, iron deficiency anaemia.

INTRODUCTION

Severe anaemia is reported to occur in severe hookworm infection in many studies.[1 to 17] Serum iron as an important indicator of iron deficiency anaemia in severe hookworm infection diagnosed by doing endoscopy is studied here.

MATERIALS AND METHODS

This study was conducted in the department of general surgery, Aarupadai Veedu Medical College and Hospital, Puducherry. A study of 1100 patients who had undergone upper gastro-intestinal endoscopy for a period of four and half years from May 2009 to October 2013 was carried out. In each of these 1100 patients, the first and second part of duodenum were carefully examined to find out the presence of single or multiple hookworms. In all the patients found to have hookworms in duodenum, investigations were done to know about the presence of severe anaemia. In patients with severe anaemia[haemoglobin <7g/dl or g%] peripheral smear examination was also done in addition to haemoglobin estimation. But in one patient with severe anaemia, in addition to haemoglobin estimation and peripheral smear examination which indicate iron deficiency anaemia, serum iron is also done. Severe anaemia is taken as haemoglobin <7g/dl or g%. Normal serum iron is 50 to 170 μg/dL.

The results were found as given below.

RESULTS

Out of these 1100 patients, 14 patients found to have hookworms in duodenum while doing upper gastrointestinal endoscopy were taken into consideration for our study. Out of these 14 patients, 9 patients had anaemia and 2 of these 9 patients were found to have severe anaemia[haemoglobin <7g/dl or g%]. Severe anaemia indicates significant loss of blood which will occur only due to heavy burden of hookworms in severe hookworm infection. The peripheral smear of both the patients showed severe hypochromic anaemia. In one patient with severe anaemia due to severe hookworm infection, in addition to low haemoglobin and microcytic
hypochromic RBCs in peripheral smear examination which indicate iron deficiency anaemia, serum iron is also found to be very low. The results were found as given below.

**Detailed investigations which indicate iron deficiency anaemia in one patient with severe hookworm infection diagnosed by doing endoscopy in our study.**

**a. Low haemoglobin**
In this patient with severe anaemia due to severe hookworm infection with multiple hookworms in duodenum diagnosed by doing endoscopy, haemoglobin is very low-3.2 g% [normal range 12 to 16 g%].

**b. Peripheral smear examination**
In this patient with severe hookworm infection, peripheral smear examination showed severe microcytic hypochromic anaemia.

c. **Low serum iron**
In this patient with severe hookworm infection, serum iron is very low-20 μg /dL [normal range 50 to 170 μg/dL].

Hence in addition to low haemoglobin and microcytic hypochromic RBCs in peripheral smear examination which indicate iron deficiency anaemia, low serum iron is also as an important indicator of iron deficiency anemia in severe hookworm infection diagnosed by doing endoscopy.

Multiple hookworms in duodenum in this patient with severe anaemia [haemoglobin 3.2 g %] due to severe hookworm infection diagnosed by doing endoscopy is shown in fig 1, 2, 3.

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**Fig 1:** Multiple hookworms in duodenum in a patient with severe anaemia [haemoglobin 3.2 g %] due to severe hookworm infection.
Fig 2: Multiple hookworms in duodenum in the same patient with severe anaemia [haemoglobin 3.2 g%] due to severe hookworm infection [different view]

Fig 3: Multiple hookworms in duodenum in the same patient with severe anaemia [haemoglobin 3.2 g%] due to severe hookworm infection [different view]
DISCUSSION

There are two human-specific hookworms, namely Ancylostoma duodenale and Necator americanus. The most common laboratory finding in hookworm infection is iron deficiency anemia. The degree of anemia depends on hookworm burden and the species, because Ancylostoma duodenale causes more blood loss than Necator americanus. Iron deficiency anemia secondary to loss of iron into the gut is the most significant risk of hookworm infection.[19]

Storage, transport and functional compartments for iron

Iron-containing compounds in the body are one of three types: a) storage forms for iron and b) compounds that serve as transport and c) functional compounds that serve in metabolic or enzymatic functions.[18]

- Ferritin is the primary storage compound for the body's iron. 30% of iron in the body is stored as ferritin in the spleen, bone marrow and the liver.
- Iron is distributed within the body via transferrin in the plasma, a transport protein that mediates iron exchange between tissues.
- Hemoglobin constitutes the major fraction of body iron (functional iron). 65% of iron in the body is bound up in haemoglobin.[18]

Iron in the body (transport compartment bound to transport protein–transferrin)

The metabolism of all living organisms requires iron. The amount of circulating iron bound to transferrin is reflected by the serum iron level.

The plasma or serum pool of iron is that fraction of all iron in the body that circulates bound primarily to transferrin.[19] The iron in this pool turns over very quickly and represents iron in transit from one location to another e.g. from absorptive cells to erythrocytes developing in the bone marrow.[19] More than 80% of the iron in plasma is taken up by developing erythroblasts in the bone marrow.[19] Hence 65% of iron in the body is bound up in haemoglobin and is found in red blood cells as heme in hemoglobin. Iron is a part of heme, which is the active site of peroxidases that protect cells from oxidative injury by reducing peroxides to water.

Serum iron level

The important way of assessing the amount of iron in the plasma or serum is by measuring the total iron content per unit volume in μg/dl.[19] The serum iron reference range is 55–160 μg/dL in men and is 40–155 μg/dL in women. Diurnal variation is observed with serum iron testing; normal values are found in the mid-morning, low values are found in mid-afternoon, and even lower values are found near midnight. Diurnal variation disappears at values below 45 μg/dL.

Serum iron level in iron deficiency anemia

The following is observed in patients with severe uncomplicated iron deficiency anemia:

1. RBCs are hypochromic and microcytic.
2. The plasma iron concentration or serum iron level is decreased.

The normal plasma iron concentration ranges between 50–170 μg/dL.

Iron deficiency anaemia in adults

Iron deficiency anaemia (IDA) in adults occurs typically due to a gradual decline in the iron content of the body due to a loss of haemoglobin.[19] Hence iron deficiency anaemia is defined as low haemoglobin concentration below the expected values and is also characterised by microcytic anaemia and low serum iron concentration.[19] Blood loss from the gastro-intestinal tract is the common cause of iron deficiency anaemia.[19] Hence hookworm infection which causes blood loss from the gastro-intestinal tract results in iron deficiency anaemia.

Investigations which indicate iron deficiency anaemia

The various investigations which indicate iron deficiency anaemia are haemoglobin estimation, peripheral smear examination and serum iron.

- a. Low haemoglobin in iron deficiency anaemia

Hemoglobin constitutes the major fraction of body iron (functional iron) with a concentration of about 0.5 mg iron/mL blood.[18] 65% of iron in the body is bound up in haemoglobin.[18] Anaemia is defined as the reduction in haemoglobin concentrations below the expected values[WHO,1972]. Haemoglobin levels were based on the World Health Organisation standards of 13 g/dl for adult males, 12 g/dl for adult women and 11 g/dl for pregnant women and preschool children below which were considered to have iron deficiency anaemia.[13] In iron deficiency anaemia haemoglobin is low.

- b. Peripheral smear examination in iron deficiency anemia

Patients with iron deficiency anaemia have microcytic hypochromic RBCs on peripheral smear indicating that the RBCs are very small with small volume and are microcytic and RBCs are hypochromic and have low amount of haemoglobin.

- c. Low serum iron in iron deficiency anemia

Iron is distributed within the body via transferrin in the plasma, a transport protein that mediates iron exchange between tissues. The amount of circulating iron bound to transferrin is reflected by the serum iron level. Normal serum iron is 50 to 170 μg/dL. In iron deficiency anaemia serum iron is low.

Serum iron as an important indicator of iron deficiency anaemia in severe hookworm infection diagnosed by doing endoscopy in our study compared with other studies

a. Our study

In our patient with severe hookworm infection with multiple hookworms in duodenum diagnosed by doing
endoscopy, in addition to very low haemoglobin of 3.2 g% and microcytic hypochromic RBCs in peripheral smear examination which indicate iron deficiency anaemia, serum iron is also found to be very low-20 μg/dL [normal range 50 to 170 μg/dL].

b. Other studies
In many other studies also, in patients with severe hookworm infection with multiple hookworms in duodenum diagnosed by doing endoscopy, in addition to very low haemoglobin and microcytic hypochromic RBCs in peripheral smear examination which indicate iron deficiency anaemia, serum iron is also found to be very low(1,2, 6, 14, 15, 17).

1. In the study conducted by Hyun HJ et al (1) in Korea, a 82-year-old female patient suffered from severe dyspnea and dizziness. Laboratory results revealed: very low hemoglobin 3.4 g/dL (normal 12-16 g/dL), microcytic and hypochromic RBCs indicating iron deficiency anaemia and also very low serum iron 9 μg/dL (normal 37-145 μg/dL). Gastrroduodenoscopy observed hyperemic mucosa of the duodenum and discovered numerous moving roundworms on the mucosa. Endoscopy isolated seven of them, which were identified as Necator americanus.

2. In the study conducted by Wu KL et al (2) in Taiwan, a 78-year-old man complained of intermittent black color stool passage for 4 months. Laboratory data showed very low hemoglobin of 3.7 g/dL with microcytic hypochromic erythrocytes indicating iron deficiency anaemia and also decreased serum iron. Upper gastrointestinal endoscopy showed live worms measuring 4-6 mm in length in the second portion of the duodenum. They were removed by using the biopsy forceps and these worms were identified as adult hookworms of Necator americanus species.

3. In the study conducted by Lee T.-H et al (6) in Taiwan, a 87-year-old male farmer complained of exertional dyspnea. Laboratory data showed very low hemoglobin of 3.9 g/dL indicating iron deficiency anaemia and also very low serum iron -12 μg/dL (normal range 50 to 170 μg/dL). Upper gastro intestinal endoscopy showed several thin worms in the gastric antrum and duodenal bulb. The worms were removed by biopsy forceps, and were identified as being Necator americanus from their characteristic morphology.

4. In the study conducted by Yan SL et al (14) in China, a 60-year-old male farmer presented with intermittent melena and anaemia for 1 month. Laboratory data revealed very low haematocrit of 24.2% (normal: 42-52%) indicating iron deficiency anaemia and also low serum iron 19 μg/dL (normal: 33-167 μg/dL). The patient underwent push enteroscopy, demonstrating several reddish worms grazing in the duodenum. Three worms were removed with biopsy forceps and were identified on microscopic examination as hookworm, Necator americanus.

5. In a study conducted by Genta RM et al (15) in Texas in a patient with pale skin upper gastro intestinal endoscopy was performed. Several small, translucent red-appearing worms measuring between 6 mm and 1 cm in length were seen in the descending duodenum. Laboratory data showed very low hemoglobin of 4.9 g/dL and a very low hematocrit of 16.8% (normal: 42-52%) indicating iron deficiency anaemia and also very low serum iron -6.0 μg/dL (normal range 50 to 170 μg/dL).

6. In the study conducted by Bamanikar S et al (17) in Pune, Maharashtra, India, a 35-year-old male presented with very low hemoglobin: 4.6 g/dL (normal 12-16 g/dL) with microcytic hypochromic erythrocytes and very low hematocrit: 17.5% (normal: 42-52%) indicating severe iron deficiency anaemia and also very low serum iron 9 μg/dL (normal 37-145 μg/dL). Upper gastro intestinal endoscopy showed live worms. They were removed by using the biopsy forceps and these worms were identified as adult hookworms of Ancylostoma duodenale species histologically.

Hence in all these patients in our study and also many other studies with severe hookworm infection with multiple hookworms in duodenum diagnosed by doing endoscopy, in addition to low haemoglobin and microcytic hypochromic RBCs in peripheral smear examination which indicate iron deficiency anaemia, serum iron is also found to be very low

CONCLUSION
1. Blood loss from the gastro-intestinal tract is the common cause of iron deficiency anaemia. Hence hookworm infection which causes blood loss from the gastro-intestinal tract results in iron deficiency anaemia. Iron deficiency anaemia secondary to loss of iron into the gut is the most significant risk of hookworm infection.

2. In all the patients in our study and also many other studies with severe hookworm infection diagnosed by doing endoscopy, in addition to low haemoglobin and microcytic hypochromic RBCs in peripheral smear examination which indicate iron deficiency anaemia, serum iron is also found to be very low.

3. Hence in addition to low haemoglobin and microcytic hypochromic RBCs in peripheral smear examination which indicate iron deficiency anaemia, low serum iron is also an important indicator of iron deficiency anaemia in severe hookworm infection diagnosed by doing endoscopy.

4. Iron deficiency anaemia is defined as low haemoglobin concentration below the expected values and is also characterised by microcytic anaemia and low serum iron concentration.

5. Hence serum iron is an important indicator of iron deficiency anaemia.
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