Iron in the Human Body

Pages with reference to book, From 332 To 334

Fatema Jawad (Sughra Bai Millwalla Hospital, Karachi.)

Iron is one of the important elements necessary for the metabolism of the human body. It is found in two forms, essential iron for normal function of the body and the reserve for times of needs. The essential iron is mostly haemoproteins and is present in haemoglobin or erythron and is the major part of the body iron. It has a molecular weight of 64500 and a concentration of 1 g per kilogram of red cells. The second largest fraction is myoglobin which has a molecular weight of 17000 and a concentration of 0.01 g per kilogram of muscle. The other important position of essential iron is in enzymes required for mitochondrial function and DNA Synthesis[1]

The storage iron compounds, in the form of ferritin and haemosiderin are present mainly in the reticulo-endothelial system. Ferritin, a protein has an outershell and an inner core which contains the iron deposited as ferric hydroxy phosphate complex. The life span of this protein is only a few days[2], resulting in continuous degradation and resynthesis and a readily available iron pooi. The degraded protein along with coalesed iron which is amorphous and insoluble, is called haemosiderin. This gives a significant reaction with Prussian Blue[3].

Serum ferritin estimation is a guide to measure the total iron stores of the body.[4] One microgram of ferritin per litre represents 8 to 10 mg of storage iron.[5,6] The difficulty encountered in this method is the raised serum ferritin level in inflammation especially when an organ rich in ferritin as the liver is involved.[4] The storage iron provides an immediate supply in emergency as blood loss. Persons having 10 to 30 gm of iron reserves can mobilize upto 80mg per day.[7]

Iron is transported through plasma bound to transferrin. This is a beta globulin with a molecular weight of 80,000 and two iron binding sites. It is synthesized mainly in the liver, the action being dependent on the level of storage iron. The tissues take up iron through specific membrane receptors which vary in number.

The iron content is kept constant in the body by maintaining a balance between the amount absorbed and the amount lost. The iron requirements are for growth,[8] physiological losses[9] and uterine losses due to menstruation and pregnancy.[10] The iron available in the diet is absorbed in a small portion only.[11] This amount also depends on the interaction of foods, drugs and abnormal components of diet. Absorption is impaired by eggs and potentiated by orange juice. Individual in the habit of eating clay may form insoluble complexes in the gut making the iron unabsorbable Tetracycline and iron if administered together gives the formation of unabsorbable iron chelates leading to gross impairment of iron absorption. Heme iron has been found to be best absorbed from the intestinal lumen as an intact heme complex. It is a stable chelate and is unaffected by all the intralurninal factors. But heme iron only forms a small percentage of the dietary iron especially of the diet of the low economic class.

When iron losses exceed iron absorption, iron deficiency set in. The major iron containing compartments of the body start getting depleted. Storage iron, transport iron, erythrocyte iron and tissue iron enzymes all fall to a low level. The plasma iron and total iron binding capacity reflect the iron availability to the tissues.[12]The former value divided by latter gives the transferrm saturation. The normal range lies between 20 and 50 percent. This is an accurate gauge for assessing iron deficiency. The level falls below 16 percent in inflammation or iron lack. The differentiation between the two is done by estimation of serum ferritin, the level of which falls to 12 microgram per litre or less in iron deficiency and is disproportionately raised in inflammation.[5,13] Transferrin concentration which is increased in iron deficiency is also a supporting diagnostic factor.

Iron deficiency anaemia is prevalent all over the world.[14,15] It is found to be of a severe nature producing symptoms in the underdeveloped countries where the diet does not supply adequate iron and hookworm infestation is common.[16] Lack of iron effects the body systems and produces variable symptoms. Increased catecholamine levels in children leading to abnormal behaviour has been found associated with iron deficiency.[17] An impaired response of tri-iodothyronine to cold is also seen in subjects with low iron contents.[18] A number of metals as lead and cadmium entering the body via the iron absorptive mechanism, are liable to reach the body tissues in excessive amounts in the state of iron deficiency.[19,20] To prevent a deficiency of iron in the body, the diet should be regulated according to the needs. When treatment is necessary it is essential to determine and remove the causative factor. Ferrous salts in a total dose of 200 mg given thrice daily is the recommended therapy.

Iron overload is said to exist when the total body stores of iron are about 4gm. The macrophage and hepatocyte are mainly involved. Iron excess may be primary or idiopathic when it is HLA related, due to a somatic gene mutation,[21,22] This type of haemochromatosis is prevalent in about one person per thousand in the homozygous form. Secondary haemochromatosis is encountered particularly in homozygous thalassaemia and sideroblastic anaemia where regular blood transfusions maintain life. Occasionally iron overload develops in patients with liver disease especially cirrhosis.

Serum ferritin level is the most accurate estimation for determining iron overload.[23] Values as high as 700 microgram per litre have been obtained.[24] In the absence of inflammation and liver disease, a serum ferritin level above 300 microgram in males and above 200 microgram in females indicates increased iron stores. Transferrin saturation denotes parenchymal overloading when readings over 80% in the male and over 70% in the female are encountered; Urinary iron excretion after injecting deferoxamine is another test for excess iron in parenchymal tissues.[25] Needle liver biopsy is a practical method of determining the extent of iron deposited and tissue damage.

The clinical manifestations vary with the type of iron overload. The HLA related disorder is diagnosed accidentally or signs and symptoms may develop in the fifth or sixth decade. [24] They may be projected as either diabetes, testicular atrophy, hepatomegaly, arthritis, bronze pigmentation of the skin or cardiac failure. Patients which thalassaemia show a rapid sequence of events as hepatic fibrosis, gonadal failure and fmally cardiac death.[26] Regular phlebotomy of 500ml is recommended in patients with parenchymal overload whereas chelator therapy with deferoxamine has been used with favourable results in cases of thalassaemia.[27,28]

Being one of the essential elements for sustaining health, iron can cause a situation of alarm at both levels - low or high.

References

1. Wrigglesworth, J.M. and Baum, H. The biochemical functions of lion, in iron in biochemistry and medicine. Edited by Jacobs, A., Worwood, M. London, Acedemic Press, 1980; 29.
2. Drysdale, J.W. and Munro, H.N. Regulation of synthesis and turnover of ferritin in rat liver. J. Biol. Chem., 1966; 241: 3630.
3. Wixom, R.L., Prutkin, L. and Munro, H.N. Haemosidrin; nature, formation and significance. Int. Rev. Ex. Pathol., 1979; 22: 193.
4. Lipschitz, D.A., Cook, J.D. and Finch, C.A. A clinical evaluation of serum ferritin as an index of iron stores. N.Engl. J. Med., 1974; 290: 1213.
5. Finch, C.A., Cook, J.D., Labbe, R.F. and Culala, M. Effect of blood donation on iron stores as evaluated by serumferritin. Blood, 1977 ;50 : 441.
6. Worwood, M. Serum ferritin, iron in biochemis try and medicine. Edited by Jacobs, A, Wor-wood,

M. London, Academic Press, 1980; 203.
7. Hillman, R.S. and Giblett, E.R. Red cell membrane alteration associated with "Marrow Stress". J. Clin. Invest., 1965; 44 : 1730.
8. Dallman, P.R., Siimes, M.A. and Stekel, A. Iron deficiency in infancy and childhood. Am. J. Clin. Nutr., 1980; 33 : 86.
9. Green, R., Charlton, R.W., Seftel, H., Bothwell, T., Mayer, F., Adams, B., Finch, C. and Layrisse, M. Body iron excretion in man; a collaborative study. Am. J. Med., 1968; 45 : 336.
10. Bothwell, T.H. and Charlton, R.W. Iron deficiency in women; report for the International Nutritional Anemia Consultative Group 1980.1.
11. Hallberg, L. Bioavailability of dietary iron in man. Annu. Rev. Nutr.,2982; 1 : 123.
12. Cook, J.D. Clinical evaluation of iron deficiency. Semin. Hematol., 1982; 19 : 6.
13. Bothwell, T.H., Charlton, R.W., Cook, J.D. and Finch, C.A. Iron metabolism in man. Oxford, Blackwell, 1979, 88.
14. Nutritional anaemias; report of a WHO committee of Experts. WHO Tech. Rep. Ser., 1972; 503.
15. Nutritional anaemias; report of a WHO Scientific Group. WHO Tech. Rep. Ser., 1968; 405.
16. Bothwell, T.H., Charlton, R.W., Cook, J.D. and Finch, C.A. Iron metabolism in man. Oxford, Blackwell, 1979; p. 7.
18. Dillmann, E., Gale, C, Green, W., Johnson, D.G., Mackler, B. and Finch, C. Hypothermia in iron deficiency due to altered triiodothyronine metabolism. Am. J. Physiol., 1980; 239 : 377.
19. Valberg, L.S., Ludwig, J. and Olatunbosun, D. Alteration in cobalt absorption in patients with ` disorders of iron metabolism. Gastroenterology, 1969;56: 241.
20. Valberg, L.S., Sorbie, J. and Hamilton, D.L. Gastrointestinal metabolism of cadmium in experimental iron deficiency. Am. J. Physiol., 1976;231 : 462.
21. Simon, M., Fauchet, R., Hespel, J.P., Beaument, C, Brissot, P., Hery, B., Hita DeNerey, Y., Genetet, B. and Bourel, M. Idiopathic hemochromatosis, a study of biochemical expression in 247 heterozygous members of 63 families; evidence for a single major HLA-linked gene. Gastroenterology, 1980; 78 : 703.
22. Edwards, C.Q., Skolnick, M.H. and Kushner, J.P. Hereditary hemochromatosis contributions of genetic analysis. Prog. Hematol., 1981; 12 : 43.
23. Bassett, M.L., Halliday, J.W., Powell, L.W., Doran, T. and Bashir, H. Early detection of idiopathic haemochromatosis; relative value of serum-ferritin and HLA typing. Lancet, 1979; 2 : 4.
24. Milder, M.S., Cook, J.D., Stray, S. and Finch, C.A. Idiopathic hemochromatosis, an interim report. Medicine (Baltimore), 1980; 59 : 34.
25. Harker, L.A., Funk, D.D. and Finch, C.A. Evaluation of storage iron by chelates. Am. J. Med.. 1968:45 : 105.
26. Modell, B. Advances in the use of iron-chelating agents for the treatment of iron overload. Prog. Hematol., 1979; 11 : 267.
27. Barry, M., Flynn, D.M., Letsky, E.A. and Risdon, R.A. Long-term chelation therapy in thalassaemia major; effect on liver iron concentration, liver histology and clinical progress. Br. Med. J., 1974;2 : 16.
28. Halliday, J.W. and Powell, L.W. Iron overload. Semin. Hematol., 1982; 19 : 42.