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(Research Article)

Iron deficiency anemia in hospitalized children

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Abstract

Iron is an abundant element on earth. It is used by nearly all forms of life from micro-organisms to humans for their developmental and survival as it is part of many enzymes involved in biological processes such as DNA synthesis, oxygen transport, and cellular energy production. Anemia is the most widely recognized manifestation of iron deficiency. This study was conducted to estimate the prevalence of iron deficiency anemia, based on age, in 200 hospitalized children 0-14 years old. Hemoglobin <12g/dL was found in 54.5% of children, 69% of the children 0-2years old had Hb<12g/dL, 51% of the children 2-6years old had Hb<12g/dL, and 19% of the children 6-14years old had Hb<12g/dL. In conclusion iron deficiency anemia is prevalent in hospitalized children, infants are the group mostly affected. Iron deficiency anemia is a major health concern as it increases risk of child morbidity, impairs cognitive and physical developmental in children and reduces school performance. It is an easily treated medical condition with excellent outcome, so a meticulous clinical attention and evaluation should be kept for children of any age.

Keywords: Iron; Anemia; Children; Infants; Hospitalization**.**

1. Introduction

Iron is an widespread and abundant element on earth. It is used by nearly all forms of life from micro-organisms to humans for their developmental and survival as it is part of many enzymes involved in biological processes such as DNA synthesis, oxygen transport, and cellular energy production. Human cells need iron to produce energy as ATP by the cellular respiration process which is provided by oxidative phosphorylation at the mitochondrial cristae [1, 2]. The human body needs iron for oxygen transport, which is essential for functioning and survival of all cell types. Oxygen is transported from the lungs to total body bound to the heme group of hemoglobin in red blood cells, where iron is a central part in its structure. In muscle cells, iron binds oxygen to myoglobin, which regulates its release. The feature that makes iron indispensable to species survival is the ability to mediate electron transfer. In the ferrous state ($Fe^{2}+$), iron acts as an electron donor, while in the ferric state ($Fe^{3}+$) it acts as an electron acceptor. Ferric iron is stable but poorly soluble so it is bound to proteins, such as transferrin to gain good bioavailability. Ferrous iron is water-soluble, and its high reactivity leads to the generation of reactive oxygen, which results in cell damage, cell death and organ failure [3, 4]. As free iron is potentially toxic, there is no free iron ions in the cell, they form complexes with organic molecules.

Humans efficiently conserve and recycle iron. The human body contains 3-4grams of iron. The majority, about 2.5 grams, is contained in the hemoglobin for oxygen transport through the blood, and most of the rest is contained in ferritin complexes that are present in all cells, but mostly in bone marrow, liver, and spleen [2]. The liver stores of

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ferritin are the primary physiologic source of reserve iron in the body. A small part of body iron, about 400mg, is used by cellular proteins like myoglobin that stores oxygen, and cytochromes that perform energy-producing redox reactions. Macrophages of the reticuloendothelial system store iron as part of the process of breaking down and processing hemoglobin from the old and damaged red blood cells. The circulating pool of iron is small, about 2-4 mg, and needs to turn over every few hours to fulfill the daily requirement of iron to support erythropoiesis and other body needs, about 20-25mg [5, 6].

The majority of the dietary iron is absorbed in the duodenum by the enterocytes of the duodenal lining. In enterocytes, iron is either stored as ferritin or transported to the basal side and released into the bloodstream by ferroportin, which is the only known iron exporter on cellular level [7]. After the release, iron is bound to transferrin and distributed safely through the body. The process of iron absorption is influenced by a variety of interconnected factors, including total iron stores, the rate by which bone marrow produces new red blood cells, the concentration of hemoglobin in the blood, and oxygen content in the blood. At the systemic level, iron homeostasis is primarily regulated by hepcidin, a 25 amino acid peptide, produced in hepatocytes. Hepcidin controls iron entry into circulation from enterocytes, iron recycling macrophages, and hepatocytes by binding to ferroportin so inducing its internalization and degradation in lysosomes [8, 9].

Aim

This study aims to estimate the prevalence of iron deficiency anemia in hospitalized children and differences according to age.

2. Method and Material

This is a retrospective study. In it were enrolled 200 children 0-14 years old, hospitalized in the General Pediatric Ward in the University Hospital Center "Mother Teresa" in Tirana, Albania during January – December 2023.

Information was extracted from the medical records of the patients. The studied parameters were: age, red blood cells number, hemoglobin level, hematocrit level, mean corpuscular volume, white blood cells, platelets, C reactive protein, ferritin level, medical diagnose on admission.

3. Results

Of the 200 hospitalized children included in the study 60.5% were males and 39.5% were females. 50.5% of them were between 0-2 years old, 28.5% were between 2-6 years old, and 21% were 6-14 years old.

According to laboratory parameters 19% of the children had Red Blood Cells (RBC) < 5,000,000 cells/mm^3, 37% of the children had Hematocrit (Hct) levels <32%, 30% of the children had Mean Corpuscular Volume (MCV) < 70µm^3, 55.5% of the children had Hemoglobin (Hg) level < 12g/dl, 52.5% of the children had White Blood Cells (WBC) > 10,000 cells/mm^3, and 32% of the children had Platelets (PLT) >400,000 cells/mm^3. (Tab.1).

Table 1 Laboratory parameters

Lab. parameter	**RBC <4,000,000 cells/mm^3**	**Hct <32%**	**MCV < 70 µm^3**	**Hg < 12g/dl**	**WBC > 10,000 cells/mm^3**	**PLT > 400,000 cells/mm^3**
Percentage	19%	37%	30%	55.5%	52.5%	32%

45.5% of the children had hemoglobin within normal range (>12g/dL), 24.5% had hemoglobin level between 11-12g/dL, 19,5% of the children had hemoglobin between 10-11g/dL, 6.5% of the children had hemoglobin level between 9-10g/dL, and 4% had hemoglobin <9g/dL. (Fig.1)

Children belonging to the age-group 0-2years old had the lowest hemoglobin level. 31% of those had normal range of hemoglobin >12g/dL, 27% had hemoglobin between 11-12g/dL, 25% had hemoglobin between 10-11g/dL, 10% had hemoglobin between 9-10g/dL, and 7% had hemoglobin <9g/dL. (Fig.2)

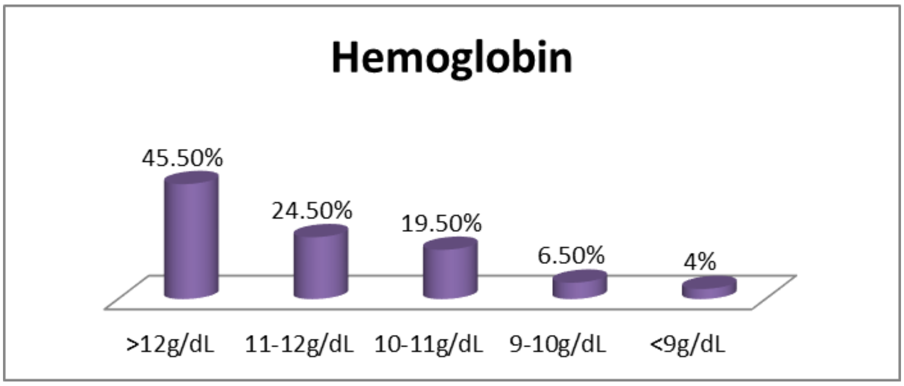

Figure 1 Haemoglobin degree (X axis haemoglobin degree, Y axis percentage of cases in children).

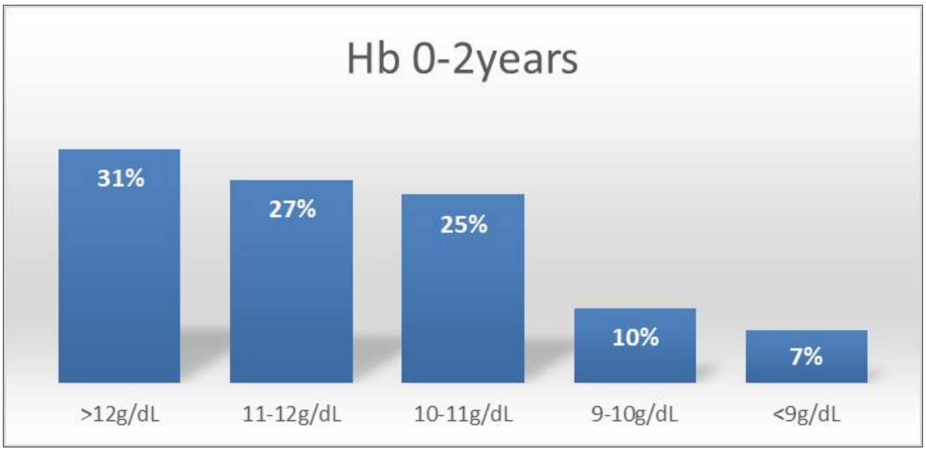

Figure 2 Haemoglobin degree in children 0-2years old (X axis haemoglobin degree, Y axis percentage of cases in children 0-2years old)

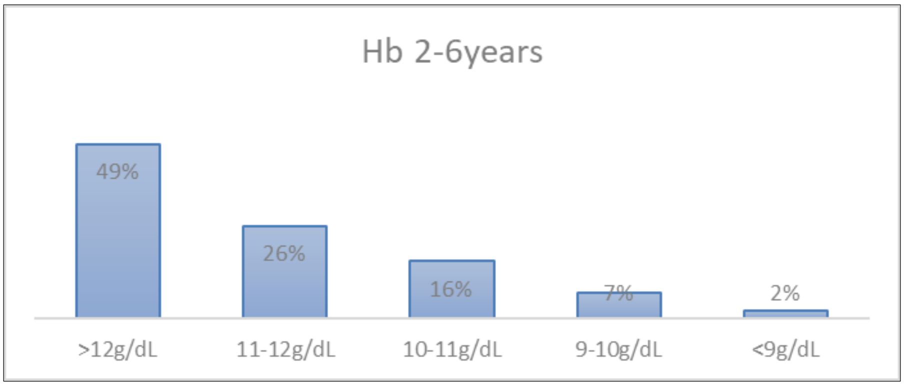

Figure 3 Hemoglobin degree in children 2-6years old (X axis haemoglobin degree, Y axis percentage of cases in children 2-6years old).

Children belonging to the age-group 2-6 years old had hemoglobin over 12g/dL in 49% of cases, hemoglobin between 11-12g/dL in 26% of cases, hemoglobin between 10-11g/dL in 16% of cases, hemoglobin between 9-10g/dL in 7% of cases, and hemoglobin lower than 9g/dL in 2% of cases. (Fig.3)

Children belonging to the age-group 6-14 years old resulted with higher degrees of hemoglobin. 81% of them had normal degrees of hemoglobin >12g/dL, 14% had hemoglobin between 11-12g/dL, and 4% had hemoglobin between 10-11g/dL. (Fig.4)

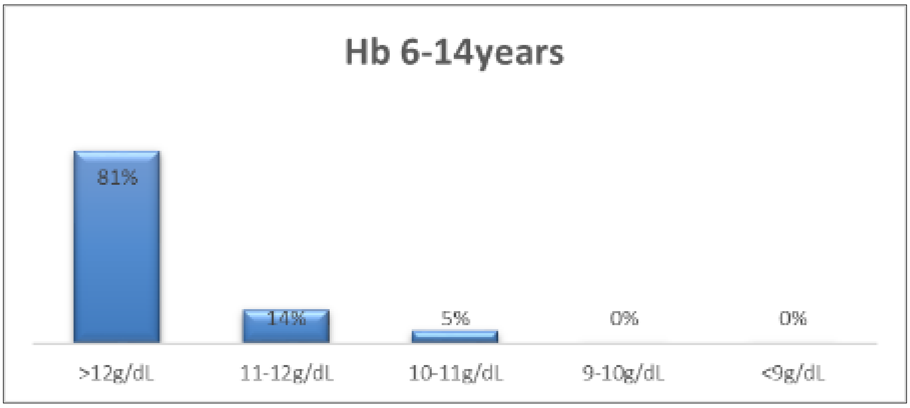

Figure 4 Haemoglobin degree in children 6-14 years (X axis haemoglobin degree, Y axis percentage of cases in children 6-14years old).

In children 0-2 years old 69% of cases had hemoglobin lower 12g/dL, whereas in age-group 2-6 years old 51% of them had hemoglobin <12g/dL, and children 6-14 years old had the lowest percentage with hemoglobin <12g/dL only 19% of them. (Fig.5)

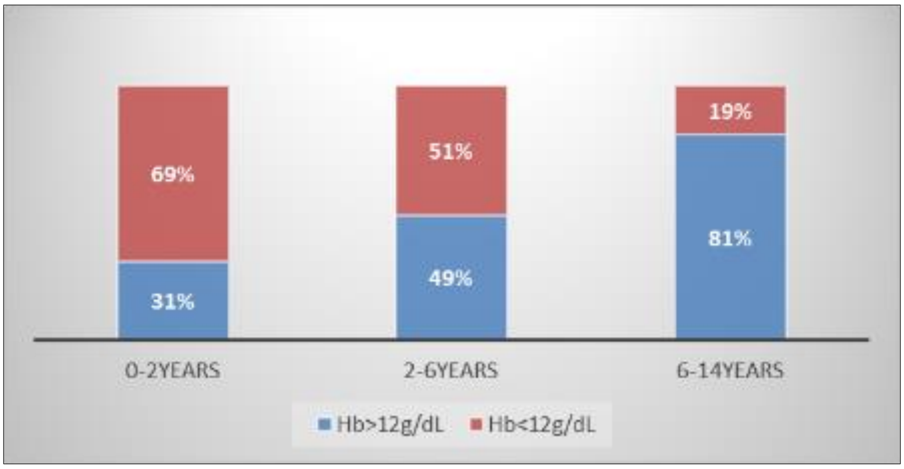

Figure 5 Anaemia according to age-groups (X axis children age divided in groups, Y axis percentage of haemoglobin according to its degrees).

Ferritin levels were found normal in 78% of children, low in 5% of them and elevated in 17% of children. 51.5% of children suffered from respiratory tract infection, 28% from gastro-intestinal tract infection, 7% of them had urinary tract infection, 5% had middle ear infection, and 8.5% of children had miscellaneous diagnosis.

4. Discussion

Iron deficiency is the most prevalent single deficiency state, and is defined as a decreased total iron body content. Iron deficiency first affects the storage of iron in the body, which is reported to be relatively asymptomatic, associated with only some vague and non-specific symptoms. As iron is primarily needed for hemoglobin synthesis, iron deficiency anemia is the primary clinical manifestation of iron deficiency. Anemia is the most widely recognized manifestation of iron deficiency. According to the World Health Organization, anemia affects nearly one quarter of the world's population, with 50% of cases attributed to iron deficiency [10,11].

Iron deficiency can be due to insufficient dietary iron absorption to fulfill the body iron needs from nutritional deficiency, malabsorption, increased iron requirements during rapid growth in children or increased blood loss [12, 13]. Iron is both necessary to the human body and potentially toxic, so keeping an equilibrium is a critical part in many aspects of human health and disease. Iron lost by shedding of intestinal epithelium, cells of the skin and minor blood loss can not be controlled, so the process of iron absorption is being controlled. The amount of iron absorbed compared to the amount ingested is low and range between 5-35% depending on the type of iron. The efficiency with which iron is absorbed depends on the source, the best absorbed is the one coming from animal products. Iron from animal products, and some plant products, is in the form of heme iron which is more efficiently absorbed from 15% to 35% of intake [14,15]. Heme iron in animals is from blood and heme-containing proteins in meat and mitochondria, whereas in plants, heme iron is present in mitochondria in all cells that use oxygen for respiration. Non-heme iron is associated with various storage proteins, including ferritin. At acidic pH in the stomach, heme is dissociated from hemo-proteins, whereas non-heme iron stabilizes in its reduced form (Fe^2+). Non-heme iron is captured by several complexes which interfere with the process of absorption, as plant-derived phytates or tannins [16].

As previously mentioned hepcedin is the major regulator of body iron balance [17]. Hepcedin expression inhibits iron absorption from the diet and iron release from recycling macrophages and other body stores. Most bacteria that cause human disease require iron to live and multiply, so in response to a systemic bacterial infection, the immune system initiates a percess known as iron withholding. Inflammatory cytokines stimulate liver to produce hepcidine which reduces available iron [18,19]. The vast majority of the hospitalized children in the study were admitted for infectious diseases and inflammatory markers (neutrophils and C reactive protein) were elevated in most of them. The enhanced inflammation was one of the factors of the relatively high prevalence of iron deficiency anemia in hospitalized children. Ferritin originates from macrophages and is measurable in serum. It generally correlates with body iron stores but is olso influenced by inflammation, infection, liver diseases and malignancies [20,21]. So ferritin level did not correlate with iron deficiency anemia in hospitalized children due to presence of inflammation. Elevated platelet count is a result of two factors, anemia due to stimulation of erythropoietin and inflammation as most of the children suffer from respiratory tract infections.

Infants (0-2 years old) was the subgroup with the highest prevalence of iron deficiency anemia. Rapid growth rate in the first two years of life together with inadequate or inappropriate feeding are the main factors for iron deficient anemia in this group. Most of the infants in Albania are breastfed which protect them against iron deficiency due to high bioavailability of iron in breast milk. However, after the first months of life, the increased erythropoiesis and the depletion of prenatal iron stores, increase the demand for iron intake, which is no longer satisfied be breast milk alone. At this point it is necessary to adequately wean in order to ensure iron-rich foods. As in most European country, even in Albania meat is an important constituent of the diet. However infants and children from lower social-economic status are prone to iron deficiency. Because child neurologic development and growth are impaired with iron deficiency, it is imperative that this condition receives adequate clinical attention and evaluation as many children are un-diagnosed or remain under-treated.

5. Conclusion

Iron deficiency anemia is prevalent in hospitalized children. Infants are the group most prone to iron deficiency. Iron deficiency anemia is a major health concern as it increases risk of child morbidity, impairs cognitive and physical developmental in children and reduces school performance. It is an easily treated medical condition with excellent outcome, so a meticulous clinical attention and evaluation should be kept for children of any age.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed Consent was taken from the parents of the hospitalized child, reported in the study, for using the data of the medical records, providing anonymity.

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