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Serum Ferritin and Iron Status of Mothers and Newborns in Lubumbashi in the DRC

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Abstract

Introduction: Ferritin is the primary form of intracellular iron storage. The serum concentration generally gives a faithful reflection of the level of iron reserves in the body. Hyperferritinemia is an early and specific marker of iron deficiency. **Methodology:** A descriptive cross-sectional study with an analytical component was carried out in DR Congo in order to determine the reference values of serum ferritin for mother-newborn couples and to establish the link between these values in mothers and their newborns. Mothers who delivered at term after a singleton pregnancy with no history of breakthrough bleeding or blood transfusion and eutrophic newborns with good APGAR showing no pathology, neither malformation, were included in the study. A blood sample was taken from the mother and the newborn for the determination of ferritin and CRP (C-reactive protein) and certain elements of the hemogram according to the methods recommended by the IFCC (International Federation of Clinical Chemistry) and ICSH (International Council for Standardization in Hematology). We have coupled the ferritin assay to CRP in order to eliminate cases of inflammatory syndrome that can influence ferritinemia. Iron supplementation and consumption of kaolin and tea during pregnancy, and some sociodemographic parameters of mothers and newborns were studied. **Results:** A total of 103 mother-newborn couples were selected. For mothers: the average age was 27.68 ± 6.42 years and the average parity was 3.80 ± 2.52. About 98.06% lived as a couple, 78.64% had a secondary education, 51.48% engaged in a revenue-generating activity and 20.40% had a poor nutritional status. Regarding the sex of the newborn, 56.3% were female. The mean serum ferritin level of the mothers is 59.21 ± 48.09 µg/l with a variability of 81.22; while it is 290.18 ± 212.69 µg/l with a variability of

73.29 in newborns. Reference values of serum ferritin ranged from 21.10 to 114.00 µg/l in mothers and 60.99 to 749.01 µg/l in newborns. There is a positive and significant correlation in the mothers between the hemoglobin level and the CCMH (0.216 and p = 0.029) and between the reticulocytes and the CCMH (0.270 and p = 0.006). In newborns, there is a positive and significant correlation between hemoglobin and ferritin (r = 0.288; p = 0.003) and between hemoglobin and TCCM (0.191 and p = 0.037). We found a positive and significant correlation between maternal ferritin and the newborn VGM (0.191 and p = 0.037). Iron Supplementation during pregnancy causes significant increase of hemoglobin in the newborn (p = 0.020). While the consumption of tea and Kaolin during pregnancy although statistically insignificant tends to decrease the values of hemoglobin, VGM, CCMH, reticulocytes and ferritin in newborns. **Conclusion:** The mother-newborn Lubumbashi has a rate of ferritin serum in usual standards. To better understand the origins-deficiency anemia of the newborn within 24 hours of birth in our midst, we propose that we consider as reference values of ferritin in serum, those in the range [60.99 - 749.01 µg/l]. Although small and not statistically significant, there is a relationship of negative correlation between ferritin maternal serum and the newborn.

Subject Areas

Gynecology & Obstetrics, Pediatrics

Keywords

Ferritin Serum, Iron Status, Mother-Newborn Couple, Lubumbashi, DRC

1. Introduction

Ferritin is the primary form of intracellular iron storage. It is a hollow protein sphere of approximately 12 nm in diameter and with a molecular mass of 440,000 g/mol [1]. It occupies a primordial place in the evaluation of iron status since its serum concentration generally gives a faithful reflection of the level of iron reserves in the body. The hypo ferritin is an early and specific marker of iron deficiency [2] [3], the dosage of serum iron is a poor indicator for assessing iron deficiency anemia because often influenced by the circadian rhythm using ferritin assay [4] [5].

From childhood, this parameter undergoes major pathophysiological changes related to a particular increase of iron requirements, to an intake deficiency sometimes relationship with socio-economic problems. This pediatric population is therefore a significant risk of developing iron deficiency [5] [6]. These iron deficiencies have significant hematological, but also extra hematological repercussions, in particular on cognitive functions and on immunity [7] [8].

In Africa, the iron deficit remains the leading cause of anemia responsible for a high infant and child mortality risk [9]. In 2012, a WHO study reported that iron deficiency is a common form of nutritional deficiency in children; it results from a prolonged imbalance in the iron balance, which is due to an insufficient supply of iron, a problem of absorption or use of iron, increased needs for iron during the period of growth or losses of blood caused by parasitic infections (malaria, helminthiasis and schistosomiasis) [10].

In the DRC, Kalenga *et al.* in 2002 reported 51.77% prevalence of anemia among children aged 1 to 2 years which they said was linked to malaria and nutritional deficiencies [11]. Recently, the EDS-DRC II (2014) reported that in the DRC nearly one in two children aged 6 to 59 months (47%) has anemia: 20% in mild form, 25% with moderate form and 2% have severe anemia. From the point of view of age, it is between 6 and 17 months that children are most affected by anemia with a prevalence varying between 51% (minimum) at 12 - 17 months and 59% (maximum) at 6 - 8 months. Although anemia can also be caused by parasitic infections, hemorrhages, congenital conditions or chronic diseases, it is most often caused by a food deficiency, including iron deficiency [12].

The approaches previously discussed have clearly shown that anemia is related to a nutritional iron deficiency, but it can also be a consequence of a chronic deficiency since neonatal period due to antenatal behaviors of mothers. Assumani *et al.* in 2018 in a study on the blood count of newborns of Lubumbashi, show that erythrocyte markers values were weak in its African population compared to the European population. The hypothesis was to know if there is a link between iron deficiency and mothers' behaviors during pregnancy, with ethnic origin and/or to genetic factors [13].

At birth, the reserve of iron is estimated by ferritin that is usually high to widely cover the needs of the chemosynthesis [14] [15] [16] [17]. In this context, an assay of the ferritin serum is a major advantage to highlight the relationship between erythrocytes markers and the rate of iron serum. So therefore, this study was aimed to determine the reference value of serum ferritin mother and newborn in the first 24 hours after birth, and to establish the link between these values.

2. Materials and Methods

2.1. Study Framework

The study was carried out in 10 health facilities, namely: the University Clinics of Lubumbashi, the Jason Sendwe hospital, the HGR Kenya, the Maternity Sainte Bernadette, the Health Center Maman wa Huruma, the Health Center Mery center, the Health Center Kenya 1, the Health Center Imani Bishop Nsolotshi and the AENEF. The selection of structures for data collection was made by reasoned choice, taking into account the following:

- welcome at least 300 newly pregnant women per year for prenatal consultations and for prenatal care;
- be accessible to all social strata of the population;
- ensuring deliveries;
- have a PMTCT service for the management of HIV infection.

2.2. Type of Study

We carried out a descriptive cross-sectional study with an analytical component, covering the period from April 10 to July 17, 2019.

2.3. Study Population and Sampling

The population study was made by the mother and newborn couples. Our sample was exhaustive.

2.3.1. Inclusion Criteria

Were included in our study; the mother and newborn couple, according to the following criteria:

- mother who freely consented to participate in the study and who did not experience bleeding from the third trimester of pregnancy;
- newborn with normal weighted futures, from a large is singleton, no history of transfusion and having no pathology involving life-threatening.

2.3.2. Criteria for Non-Inclusion

1) For the mother

Icteric, sickle cell or thalassemic mother, cesarized, multiple birth, positive TPM and anti-tuberculosis, recently transfused (less than 4 months), antimitotic, with large spleen and/or large liver, febrile, CRP positive.

2) For the newborn

Icteric Newborn, polymarformed, or with infectious stigma (sepsis), fetomaternal ABO and/or Rh incompatibility, recently transfused newborn with depressed APGAR, with iron supplementation, sick at the time of selection, positive CRP.

2.4. Study Parameters or Variables

2.4.1. For Mothers

- Age (years);
- Marital status (living alone or living as a couple);
- Professional activity (activity generating revenue or not regenerating revenue);
- Parity: nulliparous (Po), primiparous (P1), pauciparous (P2-3) and multiparous ($P \geq 4$) [18];
- Nutritional status: appreciation indicator: brachial perimeter (BP): poor nutritional status: BP < 24 cm, good nutritional status: BP ≥ 24 cm [19] [20] [21];
- Level of study: Low, if it is less than or equal to 8 years of study (2nd of secondary school); Acceptable if more than 8 years of study [22];
- Iron supplementation during pregnancy: yes or no;
- Tea consumption during pregnancy: yes or no;
- Kaolin consumption during pregnancy: yes or no.

2.4.2. For Newborns

- Gestational age (SA);

- Weight (grams);
- Gender: female and male;
- Size (cm);
- Head circumference (cm);
- Thorax perimeter (cm).

2.4.3. Erythrocyte and Biochemical Parameters (Mothers and Newborns)

- Hemoglobin (Hb) level: g/dl;
- Reticulocyte rate: %;
- Average Globular Volume (VGM);
- Average Corpuscular Hemoglobin Concentration (CCMH): g/dl;
- Serum ferritin: µg/l;
- Reactive Protein C (CRP): assay carried out by the qualitative and semi-quantitative method. CRP considered positive if greater than or equal to 6 mg/l.

The blood sample was taken on an empty stomach at the crease of the elbow, the tourniquet being weakly tight. The assay was carried out according to the methods recommended by the International Federation of Clinical Chemistry (IFCC) and by the International Council by Standardization in Heamotology (ICSH). We used the chemical PLC AU480 Beckman counter for assaying ferritin and CRP. And the SYSMEX KX21N hematology machine for the determination of erythrocyte markers. The serum ferritin assay was coupled with CRP in order to eliminate cases of acute inflammatory syndrome which could influence ferritinemia.

2.5. Data Analysis

The data processing was carried out using Epi Info 7.2.2.6 and SPSS version 23.0 software. The hemogram and ferritin values found were transformed to standard values using Z-Score to allow the values not included in the range of −2 DS and +2 DS to be located and the reference values are defined in this study as values between the 2.5th and 97.5th percentile.

Descriptive statistics made it easier for us to calculate frequencies, averages and standard deviations. The Mann-Whitney test was used to compare the means of two groups and the Rho Spearman correlation coefficient for the relationships between the parameters of the mother and those of the newborn. $p < 0.05$ was significative threshold is statistical. The study had respected the rules of confidentiality, justice and beneficence of mother-newborn couples.

The protocol for this research study was submitted and approved by the Department of Pediatrics and the Ethics Committee with the approval number: UNILU/CEM/094/2018.

2.6. Limitations of the Study

Although we have coupled the serum ferritin assay to CRP to eliminate cases of inflammatory syndrome that can influence ferritinemia, the intra-individual biological variability linked to very low serum ferritin levels can generate a bias. Hence the need, firstly, the soluble receptor assay of transferrin that we have not been able to achieve for lack of reagents and their high costs and, on the other hand, the dosage of the spinal cord ferritin, on the other hand, is an invasive method.

2.7. Ethical Considerations

Prior consent to all participants (mothers of newborn included), after clearly explained the purpose of the study has been obtained. The respect on confidentiality has been respected.

3. Results

3.1. Sociodemographic Characteristics of the Mother

The variables sociodemographic taken are in Table 1 reported that 76 mothers or 73.79% were aged from 20 - 35 years. The average age is 27.68 ± 6.42 years with such extreme 16 and 42 years. Regarding marital status, 101 mothers or 98.06% lived in a couple against only 2 or 1.94% who lived alone. In connection with the profession of a woman two had a professional regenerative recipe. Furthermore, the level of education was acceptable (78.64%). As for parity, 49.50% of pregnant women were multiparous with an intergenic space beyond 24 months in 44.70% of cases. Iron supplementation was made in 19.40% of cases, the consumption of tea and Kaolin were respectively observed in 85.40% and 84.50% of cases. The majority of mothers had good nutritional status (79.61%).

3.2. Parameters Related to Newborns

3.2.1. Sex

Figure 1 reports 58 female newborns, or 56.3%. The sex ratio Male/Female was 0.77 for females.

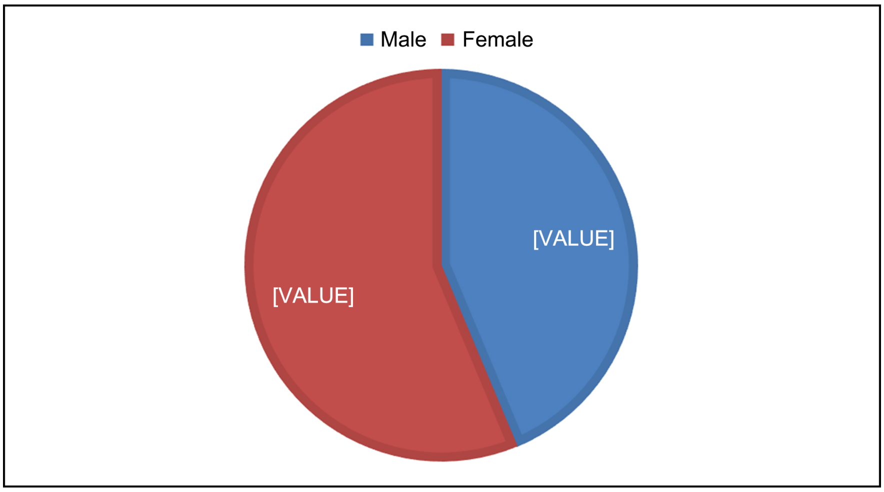

Figure 1. Sex of the newborn.

Table 1. Sociodemographic characteristics of the mother.

Age (years)	Workforce (n = 103)	Percentage	M ± SD
<20	10	9.71	27.68 ± 6.42
20 - 35	76	73.79	
>35	17	16.50	
Marital status			
Living alone	2	1.94	
Living as a couple	101	98.06	
Profession			
Recipe regenerator	53	51.46	
Non-regenerative of recipes	50	48.57	
Study level			
Low	22	21.36	
Acceptable	81	78.64	
Parity			
Primiparous (p = 1)	21	20.40	
Pauciparous (p 2 - 3)	31	30.10	
Multipar (p ≥ 4)	51	49.50	
Intergenerational space (months)			
<12	18	17.50	
12 - 24	31	30.10	
>24	46	44.70	
Not precise	8	7.80	
Nutritional status			
Bad	21	20.39	
Well	82	79.61	
Iron supplementation			
No	83	80.60	
Yes	20	19.40	
Kaolin consumption			
No	15	14.60	
Yes	88	85.40	
Tea consumption			
No	16	15.50	
Yes	87	84.50	

3.2.2. Gestational Age and Anthropometric Parameters of the Newborn

As shown in Table 2, the mean gestational age was 39.67 ± 1.26 weeks. The anthropometric parameters of the newborn varied as follows: the weight 3065.58 ± 433.83 g, the size 48.17 ± 1.91 cm, the cranial perimeter 34.80 ± 1.14 cm, the perimeter thoracic 33.19 ± 1.62 cm, the upper arm 10.84 ± 1.05 cm. It was observed that only the weight exhibited a fairly large variability.

3.3. Erythrocyte Parameters and Organic Chemicals from the Mother and Newborn

As shown in Table 3, the biological parameters of the mother give a mean serum ferritin 59.21 ± 48.09 mg/l with high variability (81.22) compared to that of the newborn is of 290.18 ± 212.69 µg/l with fairly low variability (73.29).

3.4. Reference Values Erythrocyte and Organic Chemicals from the Mother and Newborn

As shown in Table 4, reference values of serum ferritin in the mother vary from 21.10 to 114.00 g/l and in the newborn, it varies from 60.99 to 749.01 g/l.

3.5. Correlation Parameters Erythrocyte and Organic Chemicals from Mother

As shown in Table 5, the matrix of correlation of mother's biological parameters

Table 2. Gestational age and anthropometric parameters of newborns.

Parameters	N	Average	Coefficient of variation
Gestational age (SA)	103	39.67 ± 1.26	3.17
Weight (g)	103	3065.58 ± 433.83	14.15
Height (cm)		48.17 ± 1.91	3.97
Head circumference (cm)	103	34.80 ± 1.14	3.28
Thoracic perimeter (cm)	103	33.19 ± 1.62	4.88
Brachial perimeter (cm)	103	10.84 ± 1.05	9.69

Table 3. Mean and standard deviation of erythrocyte parameters and organic chemicals from the mother and newborn.

Parameters	N	Mother	Coefficient of the variation	Newborn	Coefficient of variation
Hemoglobin level (g/dl)	103	10.16 ± 1.47	14.47	17.28 ± 2.27	13.14
VGM (fl)	103	84.70 ± 8.35	9.86	96.28 ± 21.98	22.83
CCMH (g/dl)	103	28.82 ± 2.18	7.56	30.2 ± 2.40	7.82
Reticulocytes (%)	103	0.86 ± 0.29	33.72	1.11 ± 0.39	7.82
Serum ferritin (µg/l)	103	59.21 ± 48.09	81.22	290.18 ± 212.69	73.29

shows a positive and significant correlation (0.216; p = 0.029) between the hemoglobin and the rate of MCHC. A positive and very significant correlation (0.270**; p = 0.006) between reticulocytes and CCMH. Furthermore, the non-significant negative correlation (−0.131; p = 0.186) between the hemoglobin level and the reticulocytes and a non-significant positive correlation (0.156; p = 0.426) between the reticulocyte level and the serum ferritin.

3.6. Correlation Parameters Erythrocyte and Organic Chemicals in the Newborn

As shown in **Table 6**, the correlation matrix of newborn's biological parameters reported a positive correlation and very significant (0.288, p = 0.003) between the hemoglobin and ferritin. A significant positive and t correlation (0.205; p = 0.037) between the hemoglobin level and the CCMH.

3.7. Correlation Parameters Erythrocyte and Organic Chemicals in Infants (Newborn) and Ferritin Mother

As shown in **Table 7**, the correlation matrix of s parameter s erythrocyte newborn and maternal ferritin shows a correlation positive and significant (0.191, p = 0.037) between the baby MCV and ferritin maternal serum.

Table 4. Values references erythrocyte and organic chemicals from the mother and newborn.

Setting	N	Mother	Newborn
Rate of hemoglobin (g/dl)	103	6.96 to 12.29	12.90 to 21.40
VGM (fl)	103	69.22 to 97.11	24.10 to 114.13
CCMH (g/dl)	103	24.90 to 32.66	24.10 to 33.80
Reticulocytes (%)	103	0.60 to 1.60	0.60 to 2.00
Serum ferritin (µg/l)	103	21.10 to 114.00	60.99 to 749.01

Table 5. Correlation parameters erythrocyte and organic chemicals from mother.

	Rate of hemoglobin (g/dl)	VGM (fl)	CCMH (g/dl)	Reticulocytes (%)	Serum ferritin
Hemoglobin level (g/dl)		0.185	0.029	0.186	0.426
VGM (fl)	0.132		0.652	0.713	0.473
CCMH (g/dl)	0.216*	−0.045		0.006	0.071
Reticulocytes (%)	−0.131	−0.037	0.270**		0.115
Serum ferritin (µg/l)	0.079	0.071	0.042	0.156	

**The correlation is significant at the 0.01 level (bilateral); *The correlation is significant at the 0.05 level (bilateral).

Table 6. Correlation parameters erythrocyte and organic chemicals in the newborn.

Correlation	Serum ferritin	Rate of hemoglobin (g/dl)	VGM (fl)	CCMH (g/dl)	Reticulocytes (%)
Serum ferritin		0.003	0.753	0.106	0.929
Hemoglobin level (g/dl)	0.288**		0.699	0.037	0.686
VGM (fl)	0.031	0.039		0.871	0.375
CCMH (g/dl)	0.160	0.205*	−0.016		0.800
Reticulocytes (%)	0.009	−0.040	0.088	0.025	

**The correlation is significant at the 0.01 level (bilateral); *The correlation is significant at the 0.05 level (bilateral).

Table 7. Correlation parameters erythrocyte and organic chemical in infants (n-born) and ferritin mother.

Correlation	Maternal ferritin	Ferritin newborn	N-born hemoglobin	VGM newborn	CCMH newborn	Reticulocytes No baby
Maternal ferritin		0.917	0.808	0.037	0.707	0.823
Ferritin n-born	−0.010		0.011	0.538	0.316	0.876
N-born hemoglobin	0.022	0.231*		0.860	0,020	0.552
VGM born	0.191*	0.057	0.016		0.531	0.574
CCMH n-born	−0.035	0.092	0.212*	−0.058		0.349
Baby reticulocytes	−0.021	−0.014	−0.055	0.052	0.086	

3.8. Iron Supplementation during Pregnancy in the Mother, Erythrocyte Parameters and Ferritin in the Newborn

As shown in Table 8, iron supplementation in mothers in the third quarter brought a slight Amelio ration red cell parameters of the new-born but not significant for most except for hemoglobin for which the difference is statistically significant (p = 0.020).

3.9. Tea Consumption during Pregnancy in the Mother, Erythrocyte Parameters and Ferritin in the Newborn

As shown in Table 9, the consumption of tea in the mother, although not statistically significant, a tendency to decrease the erythrocyte values in newborn.

3.10. Consumption of Kaolin during Pregnancy in the Mother, Erythrocyte Parameters and Ferritin of the Newborn

Kaolin consumption in the mother, although not statistically significant, is a tendency to decrease the biological values of the new-born (Table 10).

Table 8. Iron supplementation in the mother and in erythrocyte ameters of the newborn.

Parameters	Iron supplement		p-value
	Yes (n = 20)	No (n = 83)	
Hemoglobin level (g/dl)	18.23 ± 1.87	16.86 ± 2.29	0.020*
VGM (fl)	82.91 ± 29.51	94.26 ± 19.75	0.210
CCMH (g/dl)	30.48 ± 2.88	30.64 ± 2.29	0.854
Reticulocytes (%)	1.05 ± 0.35	1.04 ± 0.40	0.954
Ferritin (µg/l)	285.67 ± 197.29	205.85 ± 215.69	0.253

*P-value is significantly less than 0.05.

Table 9. Consumption of tea at the mother, erythrocyte ferritin parameters and newborn.

Parameters	Tea		p-value
	Yes (n = 21)	No (n = 82)	
Hemoglobin level (g/dl)	17.29 ± 2.34	17.22 ± 1.91	0.916
VGM (fl)	97.00 ± 22.36	96.62 ± 20.50	0.949
CCMH (g/dl)	30.80 ± 2.34	30.23 ± 2.74	0.391
Reticulocytes (%)	1.12 ± 0.41	1.07 ± 0.24	0.662
Ferritin (µg/l)	298.64 ± 215.60	244.20 ± 196.00	0.885

Table 10. Consumption of Kaolin during pregnancy in the mother, erythrocyte parameters and ferritin in the newborn.

Settings	Kaolin		p-value
	No (n = 15)	Yes (n = 88)	
Hemoglobin level (g/dl)	17.00 ± 1.54	17.32 ± 2.37	0.607
VGM (fl)	101.86 ± 6.19	96.11 ± 23.57	0,352
CCMH (g/dl)	30.10 ± 2.59	30.81 ± 2.37	0.292
Reticulocytes (%)	1.02 ± 0.35	1.12 ± 2.37	0.348
Ferritin (µg/l)	297.54 ± 251.93	288.93 ± 206.90	0.886

4. Discussion

4.1. Sociodemographic Features of Mothers

The sociodemographic profile in Table 1 reported that 76 mothers or 73.79% were aged from 20 - 35 years. The average age was 27.68 ± 6.42 years with 16 and 42 as the extreme. A study in France reported that out of 57 patients in the study, the average age was 27.6 ± 0.7 years [23]. These results are slightly lower than those of Assumani *et al.* in Lubumbashi, which have found a mean age of

29.9 ± 5.7 ans [13].

Regarding marital status, in our series the majority of mothers lived in a couple (98.06%), one in two mothers had a profession generating revenue. The most was the level of study acceptable (64%). These results are major part superimposable to those of Assumani *et al.* [13]. In relation to parity, 49.50% of cases, our pregnant women were multiparous, this result is similar to Assumani *et al.* [13] who reported more multiparous. Since, the profile of the mother in Lubumbashi has not changed as found in our study. Audrey Camizuli in France [23] reported a significant proportion of primiparous patients (45.6%).

4.2. Gestational Age and Anthropometric Parameters of the Newborn

In our series, the average gestational age was 39.67 ± 1.26 S A and the anthropometric parameters of the newborn varied as follows: weight 3065.58 ± 433.83 g, size 48.17 ± 1.91 cm, the cranial perimeter 34.80 ± 1.14 cm, the thoracic perimeter 33.19 ± 1.62 cm, the brachial perimeter 10.84 ± 1.05 cm. It was observed that only the weight exhibited quite significant variability. The parameters remained superimposable on those of Assumani *et al.* [13], and within the limits of evolution as described by the Alexander scales [24].

4.3. Average and Range of Reference Values of Erythrocytes in Mother and Newborn

The mean serum ferritin in mothers is 59.21 ± 48.09 mg/l with high variability (81.22) compared to newborn which is 290.18 ± 212.69 mcg/l with fairly low variability (73.29).

Ferritin crumb undergoes important variations during the first-year service life. Our results can be superimposed on those of Morel *et al.* [25] that in turn the first months have observed an average 254.4 mg/l. Unlike the study by Sankande *et al.,* in Ivory Coast who reported a low ferritin level of 116.20 ± 105.95 µg/l but which remains grafted with high variability [26]. The values of the newborn are much higher than adults references in our series which is at odds with previous work that reported levels in the newborn in terms of the order of 100 µg/l and peaking in the first month at 350 µg/l [27].

The concentration serum in ferritin showed strong variability which shows a wide dispersion of values in ferritin from birth, most of which are in the normal range compared with the values of the European.

The reference values of serum ferritin in the mother vary from 21.10 - 114.00 µg/l and in the newborn, it varies from 60.99 - 749.01 µg/l. These values can be superimposed on those of Maachi *et al.* who reported a reference interval ranging from 50 to 600 µg/l the serum ferritin concentration in the newborn [4]. However, through various studies on the iron status of the newborn, the authors observed averages ranging from 81 to 677 mg/l for ferritin serum [16] [17] [28] [29] [30].

Red cell markers, such as hemoglobin, the mean corpuscular volume, concentration corpuscular average hemoglobin and reticulocytes exhibited values comparable reference to those of Assumani [13], contrary to Sakande *et al.* who reported very low values [26]. By comparing the mother to the newborn; All markers were increased in the normal range in the newborn. These results are in agreement with those of the literature [31]

4.4. Correlation Matrix Parameters Erythrocyte in the Mother and in the Newborn

The correlation matrix parameters erythrocyte mother shows a positive and significant correlation (0.216; p = 0.029) between the hemoglobin and the rate of MCHC. A positive and very significant correlation (0.270**; p = 0.006) between reticulocytes and CCMH. Furthermore, the non-significant negative correlation (−0.131; p = 0.186) between the hemoglobin level and the reticulocytes and a non-significant positive correlation (0.156; p = 0.426) between the reticulocyte level and the serum ferritin.

The newborn's biological correlation matrix parameter reported a positive correlation and very significant (0.288, p = 0.003) between the hemoglobin and ferritin. A positive and significant correlation (0.205; p = 0.037) between the hemoglobin level and the CCMH. We observed a non-significant positive correlation (0.160; p = 0.106) between serum ferritin and CCMH.

The two-matrix shows that maternal serum concentration of ferritin is not bound to any parameters of iron status. In the newborn the ferritin is closely related to hemoglobin. These results corroborate with this stream of Dop *et al.* in Lomé [32] and Sakande *et al.* [26] in Ivory Coast. The authors thought that the lack of correlation between the hemoglobin level of mothers and newborns testifies to the active transfer of iron to the fetus. However, when the maternal serum iron is low, it no longer allows sufficient supplies to the fetus whose serum iron is then reduced.

4.5. Iron Supplementation in the Mother and Erythrocyte Parameters in the Newborn

In our series, iron supplementation in the mother in the third trimester brings a slight improvement in erythrocyte parameters of the newborn but not significant for most, except the hemoglobin level for which the difference is statistically significant (p = 0.020). The intake of iron during pregnancy has been shown as an effective way to fight against iron deficiency. The authors: Assumani *et al.* [13] and Dop *et al.* [32] have also dice showed.

4.6. Consumption of Tea, Kaolin in the Mother and Biological Parameters of the Newborn

The consumption of tea and the kaolin in the mother, although statistically insignificant, has the negative influence on the future of ferritin and markers erythrocyte newborn. These results corroborate those of a study carried out by WHO in 2012 [10] and by Assumani [13] who made the same observation.

5. Conclusion

The mother-newborn Lubumbashi has a rate of ferritin in serum within accepted standards. To better understand the origins of deficient anemia of the newborn within 24 hours of birth in our environment, we suggest that we consider as reference values of serum ferritin, those in the interval [60.99 - 749.01 µg/l]. Although weak and not statistically significant, there is a negative correlation between maternal serum ferritin and that of the newborn.

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Author Contributions

All the authors contributed to the realization of this work; they read and approved the final version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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