CERTAIN ASPECTS OF IRON METABOLISM IN PREGNANCY

by

D. C. Sharma*, M.Sc., Manju Bhatnagar**, M.B.B.S.
M. M. Simlot***, Ph.D.

Several studies have been carried out in the past on the placental transfer of iron using tracer technique. Most of them were confined to animals, because of the potential radioactive hazards to the foetus, but a good deal of them also applies in human subjects. Vosburgh and Flexner (1950) showed that the maternal plasma is the source of iron for the foetus and not the maternal red blood cells as was believed previously. Wohler (1956) and Nylander (1951) indicated the presence of a specific transfer mechanism located in the placenta for this purpose, and that ferrintin is involved in this process. Bothwell and associates (1958) reported that placental iron transport is a rapid, unidirectional process, occurring against a concentration gradient. Davies *et al* (1959) found that the amount of iron transported from the maternal plasma to the foetus in utero increases progressively with advancing gestation. The investigations of Hogberg and Lindvall (1964) indicated that it is essentially an active process. Wohler (1957) found that iron supply of the foetus is to a large extent independent of the amount of iron available to the mother. He also observed that there was no iron barrier in the placenta since overloading the maternal organism with iron did not result in a placental absorption block (Wohler, 1955). According to Bagley *et al* (1968) transplacental passage of iron from mother to foetus was independent of differences in iron-binding capabilities of their transferrins. Lone (1968) suggested that the placental iron uptake in situ, is primarily controlled by the rate of maternal blood flow and plasma iron concentration, and is independent of the presence of a foetus.

Thus, it appears from the foregoing citations that in pregnancy, the maternal erythroid marrow and foetal tissues compete for the available iron, and the demands of the latter are met even at the expense of the former. But all these observations relate to the normal state of iron balance of the maternal organism. Curiously, whether these generalizations would still be valid in conditions like iron deficiency, and that too in the human beings is not established. If so, it would be difficult to reconcile with the prevalence of iron deficiency anaemia in the infants and children throughout the world, as exemplified

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**Demonstrator in Biochemistry.*

***Registrar, Dept. of Gynec. and Obst.*

****Reader in Biochemistry, Agricultural Experiment Station, University of Udaipur, Udaipur.*

Dept. of Physiology and Biochemistry, R.N.T. Medical College, Udaipur.

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by several surveys (Rao *et al* 1959; Sturgeon, 1956; Patel *et al* 1960; Davis *et al* 1960; W.H.O., 1959; and A.M.A. 1968). Therefore, in order to get an insight into the influence of maternal iron deficiency on the foetal iron status, the present study was undertaken.

Material and Methods

This study was conducted on 39 parturient women admitted to the Zanana Hospital, Udaipur. The subjects were taken up at random and no effort was made to select them on the basis of age, parity, caste, religion, socio-economic status, etc. Only those cases were discarded who delivered prematurely or had other gynaecological disorders or any systemic illness. All the cases included in the study had normal spontaneous delivery after 40 ± 1 weeks of gestation.

Before the onset of labour the maternal haemoglobin was determined in the peripheral blood obtained by finger prick. Five ml. of blood was also collected during pregnancy from the antecubital vein in a special plain vial for serum iron estimation. Since the umbilical cord blood represents blood in foetal circulation (Chaudhuri and Chaudhuri, 1956), it was collected after parturition, when the cord pulsations had ceased but before the placenta had separated. The samples, were collected in two vials-one heparinised for blood haemoglobin, and another plain for serum iron determination.

The haemoglobin was determined in all the cases by Sahli's acid haematin method. The samples for iron estimation were kept at 37°C for 2 hours to allow the serum to separate. Then serum iron was estimated by our own method published elsewhere (Sharma, *et al* 1969).

The weight and sex of the newborn were also recorded.

Results and Discussion

The subjects were divided into 2 groups on the basis of their serum iron level, since it was not possible to examine liver biopsy or bone marrow for stainable iron, and because the changes in the haemoglobin and red cell morphology are very late and less specific manifestations of iron deficiency (Bainton and Finch, 1964). The women showing serum iron values within the 'normal range' (53.2-161.5 ug/100 ml) which was established earlier (Sharma, *et al* 1969; Sharma *et al* 1970) were considered as normal (without iron deficiency) and served as control (Group I). The mothers showing values below 50 ug/100 ml were considered iron deficient and, therefore, included in the group II. This contention is corroborated by the observation of Finch (1969).

Our observations regarding maternal and foetal blood haemoglobin and serum iron, together with neonatal birth weight and sex in the above two groups, are summarised and presented in the Table I. Upon statistical evaluation the foetal serum iron level in the two groups was found to be highly significantly different ($P < 0.001$); thus showing that the maternal iron deficiency does influence the foetal iron status. This means that the newborns of iron deficient mothers are likely to suffer from iron deficiency which may be aggravated with consumption of milk (which is poor in iron) and growth and con-

TABLE I

Observations on Normal and Iron Deficient Women and their Newborn Infants

Subjects	No.		Maternal		Foetal		Neonatal	
			Blood haemoglobin (g/100 ml.)	Serum iron (ug/100ml.)	Blood haemoglobin (g/100ml.)	Serum iron (ug/100ml.)	Birth weight (Kg.)	Sex ratio (Male : Female)
Group I Normal Control	15	Range	8.0–14.0	53.8–120.0	10.0–20.5	61.5–192.3	2.0–3.7	
		Mean	9.7	74.4	15.5	107.1	2.8	
		S.D.	1.7	27.2	2.7	38.4	0.19	5 : 10
		S.E.	0.4	7.0	0.7	9.9	0.05	
Group II Iron Deficient	24	Range	4.0–11.2	7.7–46.7	6.0–19.8	11.0–138.4	2.2–3.5	
		Mean	8.7	23.0	13.0	63.8	2.6	
		S.D.	1.9	14.2	3.3	36.9	0.27	13 · 11
		S.E.	0.4	2.9	0.7	7.5	0.05	
Statistical Analysis.					$t = 2.4$ $P < 0.05$ (Significant) d.f. 37	$t = 3.59$ $P < 0.001$ (Highly significant). d.f. 37	$t = 0.91$ $P > 0.40$ (Insignificant) d.f. 37	$X^2 = 1.165$ $P > 0.10$ (Insignificant). d.f. 1

comitant expansion in blood volume. Hence, it may, at least, partly explain the widespread existence of iron deficiency in infants and children. It is hoped, therefore, that the contribution of poor placental transfer of iron in the aetiology of iron deficiency anaemia will be duly appreciated.

It may be noted that in every case the value of serum iron in foetus was higher than that of its mother, which may be due to the fact that the demands of the foetus have got priority over her own requirements, and/or that there is a higher level of activity of the haemopoietic system in the foetus (Banerjee, 1953).

The foetal blood haemoglobin was significantly different statistically ($P < 0.05$) in the two groups, but the degree of significance was less; thus confirming that the available iron is always preferably utilized for haemoglobin synthesis. On the contrary, the birth weight of the newborn in the two groups was not found to be significantly different ($P > 0.10$), which means that there is no influence of maternal iron deficiency on the overall growth of the foetus.

These conclusions are consistent with the views of Patel *et al* (1968), Sisson and Lund (1958), and Bhatt *et al* (1969) that the newborn infants of anaemic mothers usually have lower haemoglobin level than their counterparts born to normal mothers. However, there is one discordant report of Vries (1953).

If this series is typical, the incidence of iron deficiency in the pregnant women of this region is 61.53%. The sex ratio of the newborn infants in normal and iron deficient groups was—male: female:: 5:10:: 13:11, respectively. This frequency distribution was found to be due merely to the chance and there was no effect of the maternal iron status upon the sex of the newborn (X2 is calculated to 1.65 which for 1 degree of freedom gives $P > 0.10$). Further, this sample of the population is taken to represent the pattern of the general population, the percentage of male and female newborns comes to 46.15 and 53.85 respectively. This means that there is a slight preponderance of females over the males.

In view of ascertaining relationship between (i) maternal and foetal blood haemoglobin, (ii) maternal and foetal serum iron, (iii) maternal blood haemoglobin and foetal serum iron, (iv) maternal serum iron and foetal blood haemoglobin, (v) maternal blood haemoglobin and neonatal birth weight, (vi) maternal serum iron and neonatal birth weight, (vii) foetal blood haemoglobin and neonatal birth weight, and (viii) foetal serum iron and neonatal birth weight, the correlation coefficients were calculated (Table II). Highly significant ($P \leq 0.001$) correlation was observed between maternal and foetal blood haemoglobin, and their serum iron levels. Significant correlation ($P < 0.05$) was also found between maternal serum iron and foetal blood haemoglobin. This can be attributed to the fact that the maternal serum iron is the precursor of foetal iron and haemoglobin as well as mother's own haemoglobin. These findings are supported by the recent report of Lane (1968) who found that placental iron uptake is dependent upon maternal plasma iron concentration, and substantiated by Patel *et al* (1968) who observed a direct relationship between maternal and neonatal haemoglobin. On the other hand, Stransky *et al* (1953) did not observe any relation between foetal and maternal serum iron and haemoglobin.

We could not find any correlation between the other variables mentioned above. This seems to be in consonance with Chaudhuri and Chaudhuri (1956) and Patel *et al* (1968) who could not find any relationship between haemoglobin and the birth weight of the newborn. The correlation between one's haemoglobin and iron was not attempted as it was already found by us to have no relation (Sharma *et al* 1970, and Sharma, *et al* 1969).

To find out whether the sex difference in newborn infants has any

TABLE II

Correlation Coefficients between various variable

	r	d.f.	P	Comment
Between maternal and foetal blood haemoglobin.	+0.750	37	<0.001	Highly significant
Between maternal and foetal serum iron..	+0.663	37	<0.001	Highly significant
Between maternal blood haemoglobin and foetal serum iron.	—0.002	37	>0.10	Insignificant
Between maternal serum iron and foetal blood haemoglobin.	+0.329	37	<0.05	Significant.
Between maternal blood haemoglobin and neonatal birth weight.	—0.234	37	>0.10	Insignificant
Between maternal serum iron and neonatal birth weight.	+0.104	37	>0.10	Insignificant
Between foetal blood haemoglobin and neonatal birth weight.	+0.033	37	>0.10	Insignificant
Between foetal serum iron and neonatal birth weight.	+0.p41	37	>0.10	Insignificant

effect upon the haemoglobin, iron or birth weight, the original observations were rearranged (Table III). The difference was found to be statistically insignificant; therefore, it is inferred that sex does not influence these values in infants as in the adults (Sharma, *et al* 1969, and Sharma *et al* 1970).

TABLE III
Observations on Male and Female Newborn Infants

Subjects	No.		Foetal: Blood haemoglobin (g/100 ml.)	Foetal: Serum iron (ug/100 ml.)	Neonatal: Birth weight (Kg.)
Group I and II	18	Range	0.6–20.5	15.4–192.3	2.3–3.7
		Mean	14.3	88.8	2.7
Male infants		S.D.	3.5	48.8	0.37
		S.E.	0.8	11.5	0.08
Group I and II	21	Range	8.0–19.8	11.0–160.0	2.0–3.4
		Mean	13.7	73.3	2.6
Female infants		S.D.	3.1	36.4	0.35
		S.E.	0.7	7.9	0.07
Statistical analysis			t = 0.56 P > 0.60 (Insignificant) d. f. 37	t = 1.13 P > 0.20 (Insignificant) d. f. 37	t = 0.60 P > 0.60 (Insignificant) d. f. 37

Summary and Conclusions

Blood haemoglobin and serum iron were determined in 39 parturient women and their cords after delivery. The weight and sex of the newborn were also noted. The following conclusions were made.

1. The incidence of iron deficiency in the pregnant women was found to be 61.53%.
2. The maternal iron deficiency was found to be shared by the newborn, although to a lesser extent.
3. The values of haemoglobin and iron were always higher in the cord blood than the maternal blood.
4. Significant correlation was observed between maternal and foetal blood haemoglobin and serum iron, and between maternal serum iron and foetal haemoglobin.
5. Maternal iron deficiency did not influence the overall growth of the foetus.
6. Maternal iron deficiency did not determine the sex of the newborn.
7. Sex distribution in the newborn infants was found to be 46.15% (males) and 53.85% (females).
8. No sex dependent difference was found to exist in haemoglobin, iron and weight of the newborn infants.

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