Fetal Iron Content Following Maternal Achylia Gastrica (35005)

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Under normal maternal conditions the bulk of iron in the rat fetus originates in maternal nonheme iron stores, especially the liver (1). Our own observations suggest that about 70% arises from liver nonheme iron. Most workers believe that in iron deficiency the rat fetus has priority of ingested iron over the mother and will continue to draw iron from the maternal liver despite her depletion (2). The present studies were designed to examine two aspects of this problem, first the ability of the mother to absorb iron for maternal and fetal needs in the face of maternal achylia gastrica and iron deficiency and second to examine the preferential distribution of iron from maternal stores and diet to the fetus under the same conditions.

Materials and Methods. Mature female Sprague–Dawley rats of about 225 g were divided into 4 groups of 10. They were maintained on a diet of Purina Chow which contained 144 to 244 ppm of iron. Group 1 were normal nonpregnant controls, Group 2 were normal pregnant controls, Group 3 were nonpregnant animals with achylia gastrica and Group 4 were pregnant animals with achylia gastrica. Achylia gastrica was produced by direct irradiation of the exposed rat stomach with 1750 rads of X-ray while the rest of the rat was shielded (3). Group 4 rats were mated five weeks after irradiation. The time sequences were as follows: day 1 enter the study, day 8 irradiation, day 45 mating, days 65–69 delivery. Thus achylia was present in groups 3 and 4 for about 60 days. Gastric pH values were checked in irradiated animals by intubation of the stomach 30 days after irradiation and again 3 or 4 days before parturition of the pregnant animals and were found to be 7.4 ± 0.9 pH units. At delivery the litters were killed with ether, weighed, and frozen for later determination of nonheme and total iron. The mothers ate the placentas and blood loss at delivery was minimal. The mothers were killed, the livers were removed, washed, weighed, and frozen. The carcasses were weighed and frozen. Nonheme iron was determined by using the Brückmann and Zondek extraction method (4) and then measuring iron content of the clear extract by atomic absorption spectrophotometry with an iron lamp. No correction factor was applied for the small amount of iron split off the nonheme iron in the extraction process. Total iron was measured on the same system after wet ashing with nitric acid and using the same batch of nitric acid as the blank.

Results. All mean results are recorded in Table I. Total rat iron was calculated by adding total carcass iron to total liver iron. Achylia gastrica was associtaed with a striking reduction in total iron and liver nonheme iron in pregnant and nonpregnant rats. Nonpregnant rat total iron fell from 21,535 to 9528 μg, a drop of 12,007 μg. Levels in pregnant animals dropped from 26,414 to 13,205 μg, or 13,209 μg. Similarly the nonheme iron in the livers fell 3274 μg in the nonpregnant animals and 1098 μg in the pregnant animals. The percentages of iron in the liver as nonheme, however, remained approximately the same, 92 and 98% in the nonpregnant groups 1 and 3, and 73 and 75% in the pregnant groups 2 and 4. Despite the great differences in total iron and in liver nonheme iron between achylia and normal pregnant rats, the fetuses got almost identical amounts of iron although the distribution to heme and nonheme differed. In fetuses from achylic mothers, 67% iron was present as nonheme iron while in the fetuses from normal mothers the value was 89%.

All fetuses of achylic mothers had higher levels of heme iron than fetuses of normal mothers. As specific examples, rat 31, an achylic mother, had fetuses with a total iron content of 2631 µg, 877 of which were present as heme; rat 36, also an achylic mother, had 2488 µg of total and 819 as heme. Rat 13, a normal pregnant animal, had fetuses with a total iron content of 2402 µg and heme iron of 289 while rat 18 had 2513 total and 301 as heme.

Discussion. In previous studies we observed that irradiation of the stomach did not lead to significant loss of body iron from the gut (5), yet in the present study it was difficult to explain in any other way, the 12 mg loss of treated nonpregnant rats over controls. The loss, however, did not complicate the analysis of distribution of iron to the fetus for it is clear that the fetuses got their full complement of iron despite over 50% reduction in maternal carcass iron, 21,-790→9951, and 70% reduction in maternal storage iron 2206→680. An interesting finding, and consistent from litter to litter, was the greater proportion of iron present as heme in fetuses from achylic mothers than in fetuses from normal mothers. Thirty-two percent of iron was present as heme iron in fetuses from achylic mothers whereas the value was only 11% in fetuses from normal mothers. One possible interpretation of this is that maternal iron deficiency is a stimulus to fetal erythropoiesis with resultant shunting of fetal nonheme iron from stores to hemoglobin synthesis.

The fall in liver nonheme iron in achylic rats during pregnancy was equivalent to 30% of the fetal iron, implying that 70% of the fetal iron must have come from oral absorption by the mother since the maternal carcass iron did not fall. On the other hand, in untreated animals the fall in liver nonheme iron was equivalent to 120% of fetal iron suggesting that more than enough was mobilized for fetal needs and that absorption by the mother played a less important role in supplying the fetus.

As to absorption of iron by pregnant rats with achylia, it is clear that they were still able to increase total body iron content by

TABLE I.

Group		Gastric pH[a] Start of Exp.	Gastric pH[a] Time of delivery	% Wt change of carcass wt	g% Hb change	Fe (µg) Carcass	Liver Total	Liver Nonheme	Fetuses Total	Fetuses Nonheme	Total
Normal rats	1 Nonpregnant	—	1.8 ± 0.94	+7	0	16,590[b]	4945	4550	—	—	21,535
	2 Pregnant	—	1.7 ± 0.3	+22	—4.7	21,790	2206	1610	2418	2162	26,414
Achylia gastrica rats	3 Nonpregnant	1.96 ± 0.8	7.39 ± 1.07	+0.4	—0.9	8225	1303	1276	—	—	9528
	4 Pregnant	2.5 ± 1.47	7.32 ± 0.9	+4.7	—1.3	9951	680	512	2574	1731	13,205

[a] ± 1 SD.
[b] Calculated µg/g × g wt.

3677 μg (13,205 — 9528) which was 75% of the efficiency of the normal animals which absorbed 4879 (26,414 — 21,535). The achylic animals, however, were not only pregnant but also profoundly iron deficient and probably should have absorbed more in response to the combined stimulus. The diet contained adequate supplies of iron, the rats looked and ate well and were normally active but their mean carcass weight gain during pregnancy was only 12 g compared with the 55 g of the normal. Malabsorption of iron seems likely to have played a part in reduced iron content of the treated mothers.

Summary and Conclusion. Isolated gastric irradiation leads to severe achlorhydria and iron deficiency in adult female rats but despite such depletion in pregnant rats, fetuses received a normal complement of iron. The distribution of iron to heme is greater in the fetuses of achylic mothers than in fetuses of normal mothers for reasons that are not clear. Achylic pregnant rats absorbed iron at 75% of the efficiency of normal pregnant rats but this was in the face of severe iron deficiency which ordinarily would be expected to induce greater absorption from an *ad libitum* diet. Overall there appears to be significant malabsorption of iron in achylic rats which is overcome to some extent during pregnancy.

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