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Malnutrition in Rats During Pregnancy and Lactation Period: A Study on Body, Spleen and Thymus Weights and Hematologic Parameters in Dams and Their Offspring

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Physiological changes in the rat dams and their offspring as sequelae of malnutrition during pregnancy and lactation and their capacity for recuperation from early malnutrition is studied. The dams were killed during the lactation period (15th and 30th days of postpartum) and the absolute and relative weights of the thymus and spleen were recorded. The following hematologic parameters were examined: red blood cell count, hemoglobin, hematocrit, mean cell volume, mean cell homoglobin, mean cell hemoglobin concentration, white blood cell count, lymphocytes, monocytes, eosinophils, polimorphonuclear neutrophil, basophils. The offspring were sacrificed at 15, 30 and 90 days of age. Their body weight and the same hematic parameters and organ weights as their mothers were determined. Results indicate a higly significant decrease in body weight and organ weights in experimental dams and an important alteration in their hematic parameters, which may be an important determinant of retardation of growth in pups, whose body and organ weights were significantly smaller than those of the controls. In addition, the hematologic parameters of the malnourished offspring were modified in relation to those of the controls at all times (15, 30 and 90 days old) studied.

Key words: Maternal malnutrition, Lactation, Growth retardation, Hematic parameters.

Under nutrition in early life produces anatomical (8, 13), neurological (22, 24), neurochemical (12, 15) and behavioral (20, 21) alterations in rats. The severity of these changes has been increased by lowering the age which the nutritional restriction is imposed or by increasing the duration of deficient diet. Data indicate that, in the rat, these alterations are most marked and least reversible during the preweaning period.

The preservation of milk production during malnutrition results from the interplay of several maternal factors, specifically the synthetic capacity of the mammary glands, the metabolic and hormonal milieu, maternal diet ad the amount of

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mobilizable tissue reserves (3). Decreases in the protein levels in the diet of lactating rats causes these females to produce a significantly lower volume of milk than normally fed dams (23). In the human, the relationship between maternal nutrient intake and the composition of lactation is known (28). The gross composition of human milk is remarkably constant among women of varying nutritional status. The amount of milk produced by nutritional depleted women is reduced, but only to a limited extent (14). An adequate composition of the milk is crucial for the survival, proper growth and development of the infant (28).

Diet and health are intimately linked. Patients with protein energy malnutrition are known to be particularly susceptible to severe infection (6), because protein-energy malnutrition often results in the impairment of functions related to cell-mediated immunity (5). In this sense, the rapid involution of the thymus in malnutrition has been known for more than a century. Protein-energy malnutrition results in marked histomorphological derangements in the thymus, including reduction in its size and weight, depletion of lymphocytes, loss of corticomedullary differentiation and other alterations. The spleen exhibits similar changes (6).

In this paper we attempt to elucidate whether the effects of combined pre and postnatal malnutrition on cells and organs of the blood and lymphoid system can be returned to normal with adequate nutrition.

Materials and Methods

Wistar rats were kept under standard conditions of light (12L-12D), temperature (23± 3°C) and absolute humidity. The animals had free access to water and were fed a standard diet (Sandersmus). The general composition of the diet was as follows in %: Water, 13; protein, 18; fat, 2.5; fiber, 5.5; starch, 35; total sugar, 3.5; ashes, 8; calcium, 1.28; phosphorus, 0.65; NaCl, 0.6; and vitamin A, 15.000 I.U./kg; vitamin D_3, 2.000 I.U./kg.

A total of 75 virgin females aged 60-70 days and weighing 222-231 g were placed in threes in separate cages with one male per cage. Copulation was verified by daily examination of vaginal smears (10.00 A.M.) for sperm (day 0 = day copulation). Pregnant females were separated at random into two groups; one control (32 animals) and the other experimental (40 animals). During their pregnancy the latter were fed 14 g of diet daily (8, 20) while the former had free access to food. Food intake of the control dams averaged 20, 25 and 29 g on the first, tenth and twenty-first day of gestation respectively. The malnourished dams lost about 27% of their body weight during gestation (9). On the day 21 after the start of the mating period, females were observed at 11.00 A.M. for birth. The litters were weighed and counted at birth. Pups were randomly fostered in litters among females giving birth on the same day. The sex of the pups was determined by anal-urethral distances. Each cage received four males and four females. The diet of experimental females during the lactation period was 21 g per day (8, 20). The food consumption of control dams during lactation period was as follows: firts day 26 g; 5th day 47 g; 10th day 60 g and 20th day 76 g. After 20 days all the animals were given free access to the standard diet but the weaning of the pup was delayed ten more days due to their marked state of undernourishment. The weight of each animal was recorded at the ages of 15, 30 and 90 days. At this same age (15, 30 and 90 days), some animals were deeply anesthetized with diethyl ether (always at 10.00 A.M.) and blood was taken from the jugular vein. The blood from animals matched by age (15, 30 days old), sex and treatment was pooled to make up a single sample. Blood

Table I. *Body weight (g) and absolute and relative organ weights (mg) in control and malnourished dams at 15 and 30 days of lactation.*
Mean ± S.E. In parentheses the number of animals studied. Rel. = % WB.

	CONTROL		MALNOURISHED				
	15 DAYS (A)	30 DAYS (B)	15 DAYS (C)	30 DAYS (D)	Comp.*	t	p
BODY WEIGHT	279.43±13.51 (15)	263.32± 5.31 (15)	193.48± 3.43 (12)	238.45± 4.62 (15)	AvsC	8.33	0.001
					BvsD	3.54	0.01
					CvsD	7.47	0.001
SPLEEN							
Abs.	914.11±93.37 (15)	943.54±37.33 (15)	492.35±11.55 (11)	805.90± 3.46 (13)	AvsC	5.79	0.001
					BvsD	2.79	0.01
					CvsD	8.47	0.001
Rel.	309.31±23.06 (15)	330.90±10.71 (14)	253.26± 8.25 (11)	324.31±19.09 (14)	AvsC	2.88	0.05
					CvsD	3.23	0.01
THYMUS							
Abs.	172.57±25.41 (15)	273.61±13.05 (15)	69.82± 7.88 (11)	152.12± 3.46 (13)	AvsC	4.95	0.001
					BvsD	6.26	0.001
					AvsB	4.15	0.001
					CvsD	5.59	0.001
Rel.	57.18± 5.08 (15)	98.55± 4.59 (15)	36.61± 4.68 (11)	60.73± 3.99 (13)	AvsC	3.05	0.01
					BvsD	6.42	0.001
					AvsB	5.76	0.001
					CvsD	4.12	0.001

* The table only shows the statistical significant differences.

(3 or 5 ml) was put into evacuated blood collecting tubes and immediately studied in a Coulter Counter Model S. The following parameters were estimated: RBC,* Hgb, Hct, MCV, MCH, MCHC, WBC. The white series was quantified by May-Grunewald-Giemsa stain: seg., band., lymph., mono. and eosin. The animals were then killed and the weight (absolute and relative) of spleen and thymus was determined. Some mothers were sacrificed during lactation (15 and 30 days) and the same hematic parameters and organ weights as their offspring were determined.

Statistical analysis of results was carried out by means of «t» test according to FISHER and YATES (10).

* *Abbreviations:*

RBC = Red blood cell count (millions per microliters of blood).
Hgb = Hemoglobin (grams per deciliter of blood).
Hct = Hematocrit.
MCV = Mean cell volume (fentoliters).
MCH = Mean cell hemoglobin (picograms).
MCHC = Mean cell hemoglobin concentration (grams per deciliter).
WBC = White blood cell count (thousands per microliter).
Seg. = Polimorfonuclear neutrophil.
Band. = Basophils.
Lymph. = Lymphocytes.
Mono. = Monocytes.
Eosin. = Eosinophils.

Results

All absolute weights of organs, spleen and thymes, were significantly increased in the control mothers. A very important recuperation in the body weight and the spleen and thymus weight occurred in

Table II. *Hematologic parameters (mean ± S.E.) in control and malnourished dams at 15 and 30 days of lactation.*
In parentheses the number of animals studied. The table only shows the statistical significant differences.

	CONTROL		MALNOURISHED				
PARAMETERS	15 DAYS (A)	30 DAYS (B)	15 DAYS (C)	30 DAYS (D)	Comp.	t	p
RBCx10^6/μl	7.18±0.11 (15)	7.30±0.14 (15)	7.08±0.10 (12)	8.36±0.84 (13)			
Hgb g/dl	15.06±0.19 (14)	15.36±0.36 (15)	13.93±0.36 (12)	14.07±0.28 (13)	AvsC	2.99	0.01
					BvsD	2.89	0.01
Hct %	45.94±0.77 (14)	46.41±1.59 (15)	44.66±1.45 (12)	43.05±1.54 (13)			
MCV fl	64.53±1.46 (15)	63.94±1.33 (15)	63.17±2.02 (12)	64.31±1.51 (13)			
MCH pg	20.92±0.36 (14)	21.29±0.30 (15)	19.18±0.63 (12)	21.31±0.44 (13)	AvsC	2.57	0.05
					CvsD	2.94	0.01
MCHC g/dl	32.78±0.86 (13)	32.77±1.12 (15)	31.48±1.52 (12)	32.34±1.30 (13)			
WBCx10^3/μl	14.57±0.62 (14)	11.44±0.73 (15)	6.81±0.36 (11)	10.28±1.14 (13)	AvsC	10.47	0.001
					AvsB	3.33	0.01
					CvsD	2.80	0.05
Seg. %	15.43±1.84 (14)	13.47±1.08 (15)	19.75±1.73 (12)	22.67±2.64 (12)	BvsD	3.63	0.01
Band. %	1.87±0.77 (15)	0.69±0.32 (12)	3.11±1.27 (9)	2.15±1.38 (13)			
Lymph. %	76.50±2.34 (14)	75.69±3.87 (15)	68.50±2.24 (12)	72.58±2.96 (12)	AvsC	2.54	0.05
Mono. %	5.33±1.37 (15)	4.81±1.02 (15)	3.67±0.57 (12)	4.69±1.71 (13)			
Eosin. %	0.80±0.43 (15)	0.75±0.32 (15)	0.67±0.27 (12)	1.31±0.34 (13)			

malnourished mothers after 10 days eating *ad libitum*. After 15 days of lactation, malnutrition produced a decrease in the relative spleen and thymus weights, but after 30 days of lactation, 10 days eating food *ad libitum*, the differences were only statistically significant in the thymus (table I).

The hematologic parameters in control and malnourished dams at 15 and 30 days of lactation show a significant decrease in the following parameters: Hgb, MCH, WBC, lymph., but produced an increase in the percentage of band (table II).

The weight of 15, 30 and 90 days old animals and the absolute and relative spleen and thymus weight are in table III. There were significant statistical differences in the body weight (males and females), controls weighing more than animals in the malnutrition group. Highly significant differences were noted in the absolute weight of the 15 and 30 day old animals; spleen and thymus weight of the experimental animals were much lower than for controls. No significant differences were observed in the absolute weight of the thymus (males and females) when the animals were 90 days old, but at the same age the absolute spleen weight in the control males was much higher than in experimentals. The relative weight of the thymus in control animals was much higher than in experimentals (except for 90 day old animals). The relative weight of control spleens when the animals were

Table III. *Effect of early pre and postnatal acquired malnutrition on body weight (g) and absolute and relative organ weights (mg) of 15, 30 and 90 day old rats.*

AGE Days		CONTROL		MALNOURISHED			t		p	
		MALE (A)	FEMALE (B)	MALE (C)	FEMALE (D)	Comp.	Abs.	Rel.	Abs.	Rel.
15	BODY WEIGHT	29.17± 1.48(23)	28.86± 1.60(19)	13.85± 0.41(25)	14.58± 0.48(18)	AvsC	10.65		0.001	
						BvsD	8.55		0.001	
	THYMUS Abs.	130.28± 8.54(17)	149.27±12.44(15)	36.78± 3.65(14)	40.14± 6.05(14)	AvsC	9.64	6.06	0.001	0.001
						BvsD	7.98	6.38	0.001	0.001
	Rel.	414.68±16.28(18)	490.71±25.60(16)	262.97±20.59(14)	288.87±29.42(13)	AvsB		2.64		0.05
	SPLEEN Abs.	113.01±11.21(16)	130.81±12.93(15)	38.84± 2.58(15)	42.64± 4.65(14)	AvsC	6.42	3.68	0.001	0.001
						BvsD	6.51	4.51	0.001	0.001
	Rel.	352.07±18.38(16)	421.56±23.73(16)	276.67± 9.69(15)	290.75±19.31(14)	AvsB		2.39		0.05
30	BODY WEIGHT	86.88± 3.72(20)	83.66± 1.97(20)	41.70± 2.12(14)	42.35± 1.93(14)	AvsC	19.00		0.001	
						BvsD	15.35		0.001	
	THYMUS Abs.	408.71±19.22(17)	415.32±17.71(16)	161.20±11.67(12)	182.92±18.74(14)	AvsC	10.24	2.97	0.001	0.01
						BvsD	9.32	2.93	0.001	0.1
	Rel.	438.83±13.69(16)	489.08±20.15(16)	363.09±24.12(13)	407.80±20.32(14)	AvsB		2.13		0.05
	SPLEEN Abs.	349.96±16.13(18)	318.93±12.49(16)	234.02± 9.45(13)	211.78±.38(13)	AvsC	5.78	6.21	0.001	0.001
						BvsD	5.67	6.35	0.001	0.001
	Rel.	382.69±12.10(18)	373.22±1.48(16)	552.58±29.06(13)	483.40±14.10(13)	CvsD		2.23		0.05
90	BODY WEIGHT	381.66± 6.66(15)	227.61± 3.57(25)	274.21± 6.63(15)	190.69± 3.89(28)	AvsC	11.84		0.001	
						BvsD	7.07		0.001	
						AvsB	22.96		0.001	
						CvsD	11.93		0.001	
	THYMUS Abs.	536.58±41.79(15)	445.66±12.78(23)	472.74±29.09(15)	417.27±17.31(27)	AvsC		2.64		0.05
						BvsD		2.72		0.01
	Rel.	135.61± 8.62(14)	199.40± 6.03(24)	165.76± 8.10(14)	221.56± 5.74(25)	AvsB	2.53	6.37	0.05	0.001
						CvsD		5.86		0.001
	SPLEEN Abs.	883.90±30.64(15)	575.45±26.82(22)	631.97±16.51(14)	523.90±22.92(27)	AvsC	7.34		0.001	
						AvsB	7.69	2.26	0.001	0.05
	Rel.	224.61± 7.14(15)	253.10± 9.25(25)	226.09± 6.09(15)	270.68±12.14(28)	CvsD	3.24	2.72	0.01	0.05

Means ± S.E. In parentheses the number of animals studied. The table only shows the statistical significant differences. Rel. = % BW.

Table IV. *Effect of early pre and postnatal acquired malnutrition on the hematologic parameters of 15 day old rats.*
Values are the Mean ± S. E. In parentheses the number of animals studied. The table only shows the stastical significant differences.

	CONTROL		MALNOURISHED				
PARAMETERS	MALE (A)	FEMALE (A)	MALE (C)	FEMALE (D)	comp.	t	p
RBCx$10^6/\mu l$	4.26±0.10 (16)	4.34±0.09 (16)	3.60±0.17 (10)	3.58±0.17 (11)	AvsC BvsD	3.72 4.35	0.01 0.001
Hgb g/dl	10.43±0.38 (16)	10.95±0.28 (16)	8.31±.57 (10)	8.09±0.61 (10)	AvsC BvsD	3.64 5.00	0.01 0.001
Hct %	31.73±0.75	32.86±0.69 (16)	25.55±1.08 (10)	25.58±1.58 (10)	AvsC BvsD	5.09 5.08	0.001 0.001
MCV fl	72.25±1.27 (16)	75.00±1.24 (16)	74.90±0.73 (10)	72.44±70 (10)			
MCH pg	22.94±0.72 (16)	22.48±0.53 (16)	24.31±0.54 (10)	24.86±0.54 (10)	BvsD	2.07	0.01
MCHC g/dl	31.79±0.80 (16)	31.57±0.56 (16)	32.68±1.03 (10)	33.15±0.83 (10)			
WBCx$10^3/\mu l$	6.68±0.46 (16)	7.03±0.57 (16)	7.41±0.61 (10)	6.84±0.61 (11)			
Seg. %	15.73±1.40 (15)	18.60±1.46 (15)	29.60±2.75 (10)	20.64±2.53 (11)			
Band. %	2.25±0.76 (16)	1.73±0.63 (15)	0.71±0.61 (7)	18.36±7.66 (11)	BvsD	2.66	0.05
Lymph.%	74.87±1.84 (15)	72.33±1.70 (15)	63.33±7.39 (10)	57.73±6.54 (11)	AvsC BvsD	2.06 2.59	0.05 0.05
Mono. %	3.07±0.93 (14)	5.44±1.06 (16)	2.10±0.71 (10)	3.09±0.85 (11)			
Eosin. %	0.60±0.28 (15)	0.00±0.00 (15)	0.30±0.16 (10)	0.18±0.13 (11)	AvsB	2.19	0.01

15 days old, was greater than in experimental animals, but when the animals were 30 days old, the results were different.

The hematologic parameters in 15 day old control and malnourished animals are summarized in table IV. Malnutrition produces a significant decrease (both, in males and females) in the more important parameters: RBC, Hgb, Hct and Lymph.

Table V lists the hematologic results in 30 day old control and malnourished animals (males and females). In experimental animals, a statistically significant decrease in the RBC, Hgb (females), Hct and WBC (males) was observed. There were significant differences (an increase) in the number of seg. In the other parameters no significant alterations were shown.

Finally, table VI presents the data of hematologic parameters of 90 day old animals (males and females). Significant differences were found in the Hct, Band., MCH and MCHC of female rats. The values of the 2 first parameters in experimental females were lower than in controls but for the 2 others, the values were higher in malnutrition animals. In regard to the males, significant differences were found in the MCH, MCHC and Mono. The first parameters in experimental animals were higher than in controls, but the percentage of Mono. in experimental males were lower than in controls.

Table V. *Effect of early pre and postnatal acquired malnutrition on the hematologic parameters of 30 day old rats.*

Values are the mean ± S.E. In parentheses the number of animals studied. The table only shows the statistical significant differences.

	CONTROL		MALNOURISHED				
PARAMETERS	MALE (A)	FEMALE (B)	MALE (C)	FEMALE (D)	Comp.	t	p
RBCx10^6/μl	5.03±0.07 (17)	5.12±0.10 (16)	4.51±0.06 (14)	4.39±0.08 (14)	AvsC	5.52	0.001
					BvsD	5.44	0.001
Hgb g/dl	10.70±0.19 (17)	11.16±0.23 (16)	10.36±0.20 (14)	9.88±0.21 (14)	BvsD	4.25	0.001
Hct %	35.19±0.73 (17)	36.53±0.94 (16)	32.28±0.60 (14)	31.41±0.78 (14)	AvsC	1.13	0.01
					BvsD	4.26	0.001
MCV fl	71.88±1.20 (16)	70.60±1.14 (15)	71.69±1.29 (14)	70.54±1.28 (13)			
MCH pg	21.46±0.55 (17)	22.10±0.38 (15)	22.93±0.36 (14)	22.74±0.31 (14)	AvsC	2.20	0.05
MCHC g/dl	30.29±0.25 (17)	31.05±1.03 (15)	31.88±0.63 (14)	31.77±0.83 (14)			
WBCx10^3/μl	8.42±0.57 (17)	8.97±0.47 (16)	8.36±1.11 (14)	7.22±0.88 (14)			
Seg. %	12.13±1.55 (16)	11.33±1.00 (15)	15.50±1.85 (14)	17.86±2.15 (14)	BvsD	2.92	0.01
Band. %	1.21±0.49 (14)	1.23±0.60 (13)	0.42±0.24 (12)	0.08±0.08 (13)			
Lymph. %	75.56±3.14 (16)	77.07±3.12 (15)	78.00±1.86 (13)	77.83±1.92 (12)			
Mono. %	4.00±0.81 (15)	5.21±1.36 (14)	3.31±0.91 (13)	2.67±0.82 (12)			
Eosin. %	0.13±0.09 (15)	0.31±0.18 (16)	0.38±0.22 (13)	0.43±0.24 (14)			

Discussion

Malnutrition in the dams during lactation produce a decrease in the body weight and in the absolute and relative weights of spleen and thymus, which is in accordance with CHANDRA (4, 5). A very important recuperation ocurred in these mothers after 10 days eating *ad libitum* (table I).

The concentration of Hgb and MCH in malnourished dams during lactation was lower with respect to the controls, as reported by other authors (30). In accordance with other results (6), there was a significant reduction in the number of lymphocytes, but all the hematic parameters experienced a very important recuperation after 10 days eating *ad libitum*. These results are similar to others obtained in human patients with protein-energy malnutrition (1), and are in agreement with the hypothesis that the abnormalities in the immune responses in malnutrition are rapidly corrected on nutritional recovery (25).

With regard to the body weight and the absolute weight of thymus and spleen of 15 and 30 day old animals (table III), our study indicates that malnourished pups shows retardation in growth and development of these organs. These results are explained by the fact that decreases in the protein levels in the diet of lactating rats cause these females to produce a significantly lower volume of milk

Table VI. *Effect of early pre and postnatal acquired malnutrition on the hematologic parameters of 90 day old rats.*
Values are the mean ± S.E. In parentheses the number of animals studied. The table only shows the statistical signifficant differences.

	CONTROL		MALNOURISHED				
PARAMETERS	MALE (A)	FEMALE (B)	MALE (C)	FEMALE (D)	Comp.	t	p
RBCx10^6/μl	7.23±0.38 (12)	7.14±0.10 (12)	7.19±0.06 (11)	7.01±0.54 (10)			
Hgb g/dl	13.35±0.70 (12)	12.99±0.28 (12)	14.63±0.18 (11)	13.56±0.23 (9)	CvsD	3.96	0.001
Hct %	44.93±3.16 (12)	48.46±1.50 (12)	39.14±0.50 (11)	41.93±3.96 (10)	BvsD	2.48	0.05
MCV fl	60.83±2.10 (12)	67.50±1.83 (12)	58.64±0.55 (11)	63.70±1.76 (10)	AvsB	2.50	0.05
					CvsD	3.00	0.01
MCH pg	18.61±0.30 (12)	18.35±0.45 (12)	20.38±0.23 (11)	20.63±0.76 (10)	AvsC	4.84	0.001
					BvsD	2.82	0.05
MCHC g/dl	29.93±1.20 (12)	26.98±1.25 (12)	34.64±0.36 (10)	31.77±1.63 (10)	AvsC	3.61	0.01
					BvsD	2.48	0.05
WBCx10^3/μl	17.87±1.73 (11)	18.08±1.73 (12)	17.45±0.59 (11)	13.59±1.53 (10)	CvsD	2.57	0.05
Seg. %	7.25±1.24 (12)	7.73±1.18 (11)	7.82±1.14 (11)	8.36±1.54 (11)			
Band. %	1.82±0.42 (11)	2.21±0.62 (12)	0.56±0.59 (9)	0.50±0.40 (8)	BvsD	2.21	0.05
Lymph. %	82.33±2.13 (12)	83.55±1.19 (11)	86.00±1.58 (10)	84.33±2.47 (9)			
Mono. %	6.00±0.62 (12)	5.09±0.48 (11)	3.20±0.77 (10)	3.18±1.07 (11)	AvsC	3.03	0.01
Eosin. %	1.18±0.49 (10)	0.73±0.20 (11)	0.40±0.23 (10)	0.91±0.39 (11)			

than normally fed dams (15) and to show severe losses in body weight (table I) in an attempt to supplement their milk output (26); such losses in body weight seem to be inefficient in increasing the milk production of these malnourished dams to any appreciable extent as reflected by the postnatal nutritional deficiences of their offspring (table III). These results are in accordance with those of other authors (23, 29).

These anatomical alterations produced by malnutrition were reflected in the hematologic parameters of the offspring (tables IV and V). There was a more important decrease in the RBC, Hgb and Hct in the malnourished rats (males and females) which may indicate an iron deficiency (16); in the 15-day-old animals, the decrease in the number of lymphocytes of malnourished animals was very important. This shows that the thymic involution mainly involves the lymphoid part (17). These hematic alterations could possibly explain the high mortality percentage among these 15 and 20-day old animals (9), and are in agreement with MARTORELL's conclusion who revealed that 57% of children dying before the age of five showed evidence of nutritional deficiences associated with immunocompetence (18).

Body weight and the absolute weight of thymus and spleen (table III) 2 months after the experimental period were significantly lower in experimental

animals than in controls. Experimentally, whether animals achieve their normal genetically determined body weight depends on the stage of development during which the deprivation is introduced and on the degree and duration of the deprivation (7, 19). Because malnutrition was imposed during the proliferative phase of growth, the rate of cell division was hindered and the ultimate number of cells reduced (27). In our experimental model, deprivation is applied during a critical time in the development of the rat. Because of this, it seems logical to believe that these animals never acquired the body weight and the absolute organ weights of the controls. The relative weight of the thymus experienced a greater growth in relation to body weight, an increase which at present is un accounted for. However, the relative weight of the spleen was not affected in the malnourished animals. The hematologic parameters in the animals two months after the experimental period showed an important recuperation in the concentration of Hgb but, the percentage of Hct was still low in the malnourished animals. When the evolution of this parameter was analyzed in undernourished offspring a decrease was always observed with respect to controls. These results may be a consequence of a certain excess of intravascular water levels found by other investigators in malnourished children (11) or perhaps an iron deficiency (16).

In the light of these results, we think that undernutrition of rats *in utero* and during the lactation period has led to profound alterations in cells and organs of the blood and lymphoid system so that even after two months of adequate nutrition, the animals still suffer some of these alterations.

Resumen

Se determinan los cambios fisiológicos en las ratas madres y sus crías como consecuencia de la malnutrición durante la preñez y la lactancia, así como su capacidad de recuperación a la malnutrición temprana. Las madres se sacrifican durante el período de lactancia (15 y 30 días después del parto) y se registra el peso absoluto y relativo del timo y del bazo. En sangre se examinan los siguientes parámetros: número de eritrocitos, hemoglobina, hematocrito, volumen celular medio, hemoglobina celular media, concentración de hemoglobina celular media, número de células blancas, linfocitos, monocitos, eosinófilos, neutrófilos, polimorfonucleares y basófilos. En las crías sacrificadas a los 15, 30 y 90 días, se determina el peso corporal y los mismos parámetros hemáticos y pesos de órganos que en sus madres. Los resultados indican un descenso significativo del peso corporal y de los órganos y una alteración importante en los parámetros hemáticos de las madres experimentales, lo cual puede ser un determinante para el retraso de sus descendientes, cuyo peso corporal y de los órganos estudiados es significativamente inferior al de los controles. Los parámetros hemáticos de los descendientes malnutridos se encuentran alterados en relación con los de los controles en todas las edades estudiadas (15, 30 y 90 días).

Palabras clave: Malnutrición materna, Lactación, Retraso del crecimiento, Parámetros hemáticos.

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