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pituitary-adrenal system of the first postnatal period in some laboratory mammals. Endokrinologie *37:* 301–310 (1959).

24 Milkovic, K. and Milkovic, S.: Functioning of the pituitary-adrenocortical axis in rats at and after birth. Endocrinology *73:* 535–539 (1963).

25 Milkovic, S. and Milkovic, K.: Responsiveness of the pituitary-adrenocortical system during embryonic and early postnatal periods of life; in Bajusz, Physiology and pathology of adaptive mechanisms, pp. 28–47 (Pergamon Press, Oxford 1969).

26 Palkovits, M. and Mitro, A.: Morphological changes in the hypothalamo-pituitary-adrenal system during early postnatal period in rats. Gen. compar. Endocr. *10:* 253–262 (1968).

27 Poland, R.E.; Weichsel, M.E., and Rubin, R.T.: Postnatal maturation patterns of serum corticosterone and growth hormone in rats: effect of chronic thyroxine administration. Hormone metabol. Res. *11:* 222–227 (1979).

28 Shapiro, S.: Neonatal cortisol administration: effect on growth, the adrenal gland and pituitary-adrenal response to stress. Proc. Soc. exp. Biol. Med. *120:* 771–774 (1965).

29 Schapiro, S.; Geller, E., and Eiduson, S.: Neonatal adrenal cortical response to stress and vasopressin. Proc. Soc. exp. Biol. Med. *109:* 937–941 (1962).

30 Tang, F. and Phillips, J.G.: Pituitary-adrenal response to ether stress in the neonatal rat. J. Endocr. *75:* 183–184 (1977).

31 Ulrich, R.; Yuwiler, A., and Geller, E.: Neonatal hydrocortisone: effect on the development of the stress response and the diurnal rhythm of corticosterone. Neuroendocrinology *21:* 49–57 (1976).

32 Zarrow, M.X.; Haltmeyer, G.C.; Denenberg, V.H., and Thatcher, J.: Response of the infantile rat to stress. Endocrinology *79:* 631–634 (1966).

33 Zarrow, M.X.; Denenberg, V.H.; Haltmeyer, G.C., and Thatcher-Brumaghin, J.: Plasma and adrenal corticosterone levels following exposure of the two-day old rat to various stressors. Proc. Soc. exp. Biol. Med. *125:* 113–116 (1967).

Lionel Hary, Laboratoire de Physiologie animale, Faculté des Sciences, 33, rue Saint-Leu, 80 Amiens (France)

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Lipids and Lipoproteins in Maternal and Fetus Plasma in the Rat

J. Argiles and E. Herrera

Cátedra de Fisiología General, Facultad de Biología, Universidad de Barcelona, Barcelona, and Departamento de Investigación, Centro 'Ramón y Cajal', Madrid

Key Words. Lipoproteins · Pregnancy · Fetus · Triglycerides

Abstract. Plasma lipidic components appear augmented in 19- and 21-day pregnant rats compared with virgin controls, the greatest effect being in triglycerides, corresponding to the augmented proportion of plasma very low density lipoproteins (VLDL). The plasma lipidic components in fetuses of 19 and 21 days are lower than in their mothers, the greatest decrease occurring in triglycerides. In the plasma of 19-day fetuses, there is only one lipoprotein electrophoretic band which corresponds to the β-lipoproteins of adults (low density lipoproteins, LDL) according to its mobility and floating characteristics, while in the fetus of 21 days there are also pre-β-lipoproteins (VLDL). In the 1- and 5-day-old newborns, the four main lipoprotein fractions are already present as in the adults. The late appearance of VLDL and the lack of high density lipoproteins in the rat fetus determine various specific metabolic characteristics.

Introduction

The presence of lipids in fetus blood during late gestation in both humans (1, 20, 31) and experimental animals (19, 32) requires an appropriate transport system. The lipoprotein (LP) pattern has been studied in human cord blood but recent reported findings are conflicting. While some authors identified all of the main plasma LP fractions in adults (3, 20), others were not able to find very low density lipoproteins (VLDL) (7, 30) which are the main transport system for triglycerides of endogenous origin. In the present study we have investigated the sequential appearance of different LP fractions in the rat fetus and newborn, comparing these patterns with those of their mothers and adult virgin controls.

Materials and Methods

Female virgin Wistar rats (160–180 g) and age-matched pregnant rats at the 19th and 21st day of gestation (estimated by the appearance of spermatozoids in vaginal smears) were sacrificed by decapitation. Fetuses were rapidly extracted and also de-

Table I. Plasma concentration of proteins and lipid components in rat pregnancy

	Proteins mg/ml	Phospholipids mg/dl	Triglyceride glycerol μM/dl	Total cholesterol mg/dl	Free cholesterol mg/dl
Virgin controls	6.12 ± 0.30	72.22 ± 6.67	157.03 ± 13.95	76.31 ± 4.66	10.68 ± 2.75
Pregnant, 19 days	5.86 ± 0.19	101.32 ± 5.07	249.61 ± 13.25	105.05 ± 3.80	23.11 ± 2.90
p	NS	< 0.01	< 0.01	< 0.01	< 0.05
Pregnant, 21 days	5 99 ± 0.24	111.25 ± 7.80	289.65 ± 9.74	115.14 ± 2.58	22.72 ± 2.58
p	NS	< 0.01	< 0.001	< 0.001	< 0.05
Fetus, 19 days	1.15 ± 0.09	75.27 ± 7.87	76.29 ± 6.58	68.15 ± 5.71	12.23 ± 1.45
p	< 0.001	NS	< 0.001	NS	NS
Fetus, 21 days	1.82 ± 0.15	95.17 ± 6.42	54.74 ± 3.18	88.35 ± 2.75	13.00 ± 1.45
p	< 0.001	< 0.05	< 0.001	NS	NS

The values are means ± SEM of 5 animals/group. p corresponds to the statistical comparison between each group and the values in the adult virgin controls.

capitated. Newborns of 1 and 5 days of age were also decapitated. Blood was collected from the neck into heparinized receptacles and plasma aliquots (25 µl/plate) were processed the same day of sacrifice for electrophoresis on 1% agarose (Sigma, St. Louis) with 0.05 *M* barbital buffer, pH 8.6. After fixation with ethanol/water/acetic acid (15:4:1, by vol), the slides were stained with Sudan black B and the LP fractions were estimated by densitometry. The LP bands were quantified as a percentage of the total density in each slide. The band at origin was not considered for this calculation. Other plasma aliquots were used for lipid extraction (14) to quantify phospholipid phosphorus (13) after acid hydrolysis and total and free cholesterol (4). Another aliquot of the lipid extracts was blown to dryness under N_2, treated with activated silicic acid in chloroform and saponified with 0.7 *M* ethanolic KOH. After treatment with 0.18 *M* $MgSO_4$ and centrifugation, the glycerol was estimated enzymatically (15), its value being considered as triglyceride glycerol. Proteins were evaluated in aliquots of plasma (26). In another series, virgin adult rats, 19-day pregnant rats and their fetuses were used to collect blood on powder EDTA and 1-ml aliquots of fresh plasma (pools of all the plasma from the fetuses in each litter were used) were sequentially centrifuged under NaCl at densities of 1.006, 1.063, 1.102 and 1.200 g/l, adjusted by using an Abbe refractometer. All centrifugations were performed at 40,000 rpm for 18 h with a Beckman rotor 40.3 in a Beckman L5-75 ultracentrifuge. After each run, the floating fraction was collected by cutting the tube 1 cm from the top and the bottom fraction was adjusted to the new density with solid NaCl for the next run. Aliquots of the floating fractions were used for electrophoresis on 1% agarose and stained with Sudan black B as described above. Statistical comparison of the data was made with Student's t test.

Results

The plasma concentration of circulating lipids and total proteins in 19- and 21-day pregnant rats, their respective fetuses and adult virgin controls are shown in table I. In the pregnant rat, there were significantly augmented concentrations of plasma phospholipids, triglyceride glycerol, total cholesterol and free cholesterol, and normal concentrations of plasma proteins compared with values in virgin controls. There was a significant difference between pregnant rats at the 19th and 21st day of gestation only in the triglyceride glycerol parameter which was greater in the second group ($p < 0.05$). The plasma of 19- and 21-day fetuses contained a much lower protein concentration than their mothers while the phospholipid level remained constant. The plasma concentration of triglyceride glycerol, total cholesterol and free cholesterol were significantly lower in fetuses than in their mothers, the effect being especially notable in the triglycerides with values three to six times lower in fetuses than in their respective mothers.

Photographs of stained electrophoretic slides of representative plasma samples from each group are seen in figure 1. The plasma from pregnant rats and their virgin adult controls gave four main LP bands corresponding to the origin (chylomicrons), β (low density lipoproteins, LDL), pre-β (VLDL) and α (high density lipoproteins, HDL). In the 19-day fetuses only one band appeared. Its migration corresponds to that of the β band in the adults, while in the 21-day fetuses a new band appeared corresponding to migration of the pre-β band in adults. In the 1-day-old rat, the four bands of the adults are already clearly defined, the origin and β ones being the most pronounced, while in 5-day-old rats the pre-β and α bands are better defined. By considering the total area of the densitometric peaks corresponding to the β, pre-β and α bands, the comparative amount of each LP was calculated in the different groups, and these values are summarized in table II. Whereas the highest proportion of α-LP appears in control animals, the pre-β-LP is the most abundant fraction, in the pregnant rats these values being significantly greater than in the controls. In the 19-day fetuses, 100% of the LP found corresponded to the β fraction while in 21-day fetuses, 31% already corresponded to pre-β-LP. In these animals as in

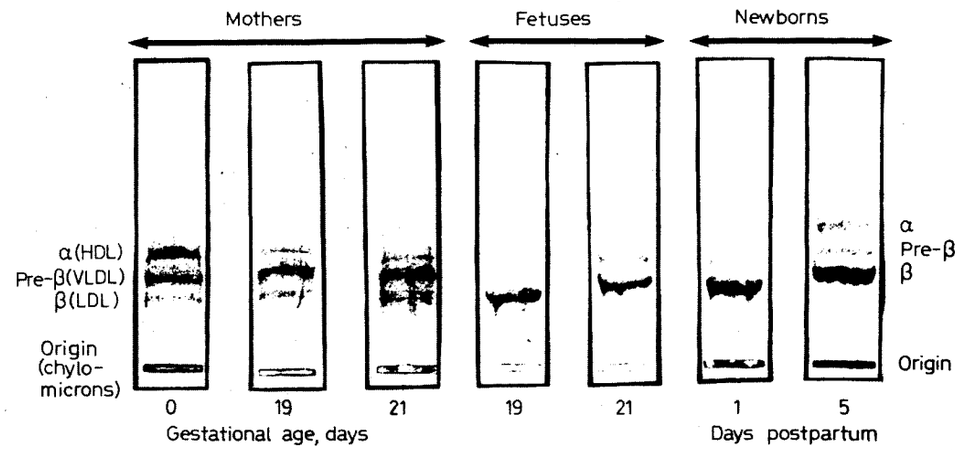

Fig. 1. Picture of representative stained electrophoretic slides of plasma samples from pregnant and newborn rats run on 1% agarose.

Table II. Percentage distribution of lipoprotein bands in rat pregnancy

	β-LP	Pre-β-LP	α-LP
Virgin controls	16.2 ± 2.1	39.7 ± 2.9	46.1 ± 4.1
Pregnant, 19 days	34.7 ± 4.5	50.9 ± 3.3	16.6 ± 2.4
p	< 0.01	< 0.05	< 0.001
Pregnant, 21 days	19.8 ± 3.7	65.2 ± 3.5	14.7 ± 1.8
p	NS	< 0.001	< 0.001
Fetus, 19 days	100	ND	ND
p	< 0.001		
Fetus, 21 days	68.5 ± 1.6	31.5 ± 1.6	ND
p	< 0.001	< 0.05	
Newborn, 1 day	74.0 ± 1.7	13.9 ± 1.1	12.1 ± 1.2
p	< 0.001	< 0.001	< 0.001
Newborn, 5 days	65.2 ± 0.9	15.5 ± 0.8	19.3 ± 0.7
p	< 0.001	< 0.001	< 0.001

The values are means ± SEM of 5 animals/group. ND = Nondetectable. p corresponds to the statistical comparison between each group and the values in the adult virgin controls.

Table III. Electrophoretic mobility of plasma lipoproteins in rat pregnancy

	β-LP	Pre-β-LP	α-LP
Virgin controls	$0.866 \times 10^{-4} \pm 0.005$	$1.156 \times 10^{-4} \pm 0.035$	$1.446 \times 10^{-4} \pm 0.039$
Pregnant, 19 days	$0.949 \times 10^{-4} \pm 0.012$	$1.256 \times 10^{-4} \pm 0.024$	$1.542 \times 10^{-4} \pm 0.018$
p	< 0.01	NS	NS
Pregnant, 21 days	$0.951 \times 10^{-4} \pm 0.045$	$1.280 \times 10^{-4} \pm 0.046$	$1.600 \times 10^{-4} \pm 0.057$
	NS	NS	NS
Fetus, 19 days	$0.833 \times 10^{-4} \pm 0.098$	–	–
p	NS		
Fetus, 21 days	$0.896 \times 10^{-4} \pm 0.011$	$1.200 \times 10^{-4} \pm 0.005$	–
p	< 0.05	< 0.001	
Newborn, 1 day	$0.905 \times 10^{-4} \pm 0.014$	$1.222 \times 10^{-4} \pm 0.068$	$1.598 \times 10^{-4} \pm 0.020$
p	< 0.05	NS	NS
Newborn, 5 days	$0.969 \times 10^{-4} \pm 0.017$	$1.226 \times 10^{-4} \pm 0.016$	$1.532 \times 10^{-4} \pm 0.007$
p	< 0.05	NS	< 0.05

Mobility has been calculated from the formula: Mobility = migration (cm) × $(\text{voltage/cm})^{-1}$ × time (min).
The values are means ± SEM of 5 animals/group. p corresponds to the statistical comparison between each group and the values in the adult virgin controls.

Table IV. Maternal and fetal plasma ultracentrifugation analysis

	Floating fractions			
	d 1.006	d = 1.006–1.062	d = 1.062–1.102	d = 1.102–1.200
Fetus, 19 days	–	+	–	–
Pregnant, 19 days	+	+	+	+
Virgin controls	+	+	+	+
	Chylomicrons and VLDL	LDL	← HDL →	

+ = Positive appearance of bands when the floating fraction was submitted to electrophoresis in agarose gels.

newborns, the most abundant fraction was the β-LP although in the latter group the α-LP are also apparent.

As it has been proposed that the electrophoretic mobility of some LP fractions in the human cord blood may be different from that in the adults (30), we have determined the mobility of each of the samples, and their values are summarized in table III. Both pre-β- and α-LP showed similar mobility in all groups where they appear, while the mobility of the β-LP was significantly greater in the 19-day pregnant rats, 21-day fetuses, and the newborns of 1 and 5 days than in adult virgin controls.

To determine, by a criterium other than electrophoresis, whether the unique LP band observed in the 19-day fetuses corresponded to LDL, plasma samples from 19-day pregnant rats, their fetuses and adult controls were processed by ultracentrifugation under different densities. As shown in table IV, in the plasma from 19-day fetuses, only one LP fraction appeared that floated at a density of 1.006–1.062 which by definition corresponds to LDL. By the same criterium, in both the plasma of 19-day pregnant rats and adult controls all the main LP fractions are present with floating characteristics that correspond to their electrophoretic mobility: chylomicrons, VLDL, LDL and HDL.

Discussion

In the present investigation it has been shown, in confirmation of previous studies (2, 18, 24, 28, 32) that in late gestation in the rat, the mother's blood is inundated with lipids composed mainly of triglycerides. This finding is consistent with the augmented proportional plasma concentration of VLDL in the mother which must be the result of both an augmented synthesis of glycerides (9, 12, 21, 32) and the reduced uptake of triglycerides by extrahepatic tissues due to the well-known decrease of LP lipase activity (18, 24, 27, 29). The role of maternal hyperlipemia for the fetus metabolic economy is not well understood because the lipids cross the placenta with difficulty (8, 23, 25). It may represent a 'fluid' energetic store that may be rapidly used in conditions of food restriction, in which case they are converted to other products – mainly ketone bodies (22, 32) – that may easily cross the placenta and be

used by the fetus (33, 34). Plasma in the fetus maintains low amounts of triglycerides until the moment of birth. Our results in the rat show that the 19-day fetus does not contain VLDL or chylomicrons in its plasma, the main transport system for triglycerides. Whether the lack of these LPs in plasma determines the maintenance of the low triglyceride levels or vice versa remains to be established.

The method used in the present study to estimate the LP fractions is based on the staining of their lipid components, the concentration and composition of which differs among the different LP classes. Thus this procedure is adequate for identification but does not allow quantitative comparisons. In the sequential appearance of LP fractions in the rat fetus at late gestation found here, the appearance of LDL prior to VLDL was remarkable, as demonstrated by both electrophoretic and ultracentrifuge analysis. A lack of VLDL in the presence of LDL has also been reported in human cord blood (7, 30), although this point is controversial (3, 20). However, the possibility that lipoprotein particles in the fetus have different physicochemical characteristics than those in adults, which would produce changes in their separation properties, as has been proposed for human cord blood (30, 36), cannot be excluded. In any case, the early and marked appearance of LDL in the fetus blood contrasts with the well-established metabolism of VLDL in adults which are secreted by the liver and converted to LDL by partial loss of their triglycerides and transfer of apoprotein-B (10, 16). Thus the site of origin of LDL in the fetus remains to be ascertained.

The absence of HDL in fetal plasma of the rat may contribute to its limited ability to deposit triglycerides in adipose tissue before birth (5, 17). These lipoproteins are known to contain cofactors such as C-II apoproteins which are powerful activators of extrahepatic LP lipase (11), and this enzyme is responsible for the removal of the VLDL triglycerides that are taken up by adipose tissue after their hydrolysis. In spite of this process, VLDL triglycerides are not augmented in late fetal blood as a consequence of their limited synthesis and/or availability from the mother and also because of the specific presence of hepatic LP lipase (27) which must contribute to their catabolism for deposit of triglycerides in the liver itself.

The onset of suckling in the newborn forces the immediate synthesis of chylomicrons in the intestinal mucose and these LP fractions appear in the plasma. This activity coincides with the appearance of HDL in the circulation, as shown here, and with the loss of LP lipase activity in liver, as previously reported (27). In this condition there is a progressive increase in LP lipase activity in extrahepatic tissues (5, 6, 19) permitting the deposit of triglycerides mainly in adipose tissue.

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References

1 Bobok, I.; Csákó, G.; Csernyánszky, H., and Ludmany, K.: Lipids in maternal, cord and newborn blood serum. Acta paediat. hung. *15:* 95–100 (1974).

2 Bosch, V. and Camejo, G.: Serum lipoproteinemia in pregnant and lactating rats. J. Lipid Res. *8:* 138–141 (1967).

3 Carlson, L.A. and Hardell, L.I.: Very low density lipoproteins in cord blood. Clinica chim. Acta *90:* 295–296 (1978).

4 Crawford, N.: An improved method for the determination of free and total cholesterol using the ferric chloride reaction. Clinica chim. Acta *3:* 357–367 (1958).

5 Cryer, A. and Jones, H.M.: The early development of white adipose tissue. Effects of litter size on the lipoprotein lipase activity of four adipose-tissue depots, serum immunoreactive insulin and tissue cellularity during the first four weeks of life in the rat. Biochem. J. *178:* 711–724 (1979).

6 Cryer, A. and Jones, H.M.: Changes in the lipoprotein lipase (clearing-factor lipase) activity of white adipose tissue during development of the rat. Biochem. J. *172:* 319–325 (1978).

7 Csákó, G.; Csernyánszky, H.; Bobok, I., and Ludmany, K.: Lipoprotein fraction in maternal, cord and newborn serum. Acta paediat. hung. *15:* 101–108 (1974).

8 Dancis, J.: The transfer of free fatty acids across human placenta; in Camerini-Davalos and Cole, Early Diabetes in early life, p. 233 (Academic Press, New York 1975).

9 Dannenberg, W.N.; Burt, R.L., and Leake, N.L.: Lipid composition and synthesis in rat liver during pregnancy and the puerperium Proc. Soc. exp. Biol. Med. *115:* 504–508 (1964).

10 Eisenberg, S.; Bilheimer, D.W.; Levy, R.I., and Lindgren, F.I.: On the metabolic coversion of human plasma very low density lipoprotein to low density lipoprotein. Biochim. biophys. Acta *326:* 361–377 (1973).

11 Eisenberg, S. and Levy, I.: Lipoprotein metabolism. Adv. Lipid Res. *13:* 1–89 (1975).

12 Fain, J.N. and Scow, R.O.: Fatty acid synthesis *in vivo* in maternal and fetal tissues in the rat. Am. J. Physiol. *210:* 19–25 (1966).

13 Fiske, C.H. and Subbarow, T.: The colorimetric determination of phosphorus. J. biol. Chem. *66:* 375–400 (1925).

14 Folch, J.; Lees, M., and Sloane Stanley, G.H.: A simple method for the isolation and purification of total lipids from animals tissues. J. biol. Chem. *226:* 497–509 (1957).

15 Garland, P.B. and Randle, P.J.: A rapid enzymatic assay for glycerol. Nature, Lond. *196:* 987 988 (1964).

16 Goldstein, J.L. and Brown, M.S.: The low-density lipoprotein pathway and its relation to atherosclerosis. A. Rev. Biochem. *46:* 897 930 (1977).

17 Hahn, P.: Lipid metabolism and nutrition in the prenatal and postnatal periods; in Winick, Nutrition and development, p. 99 (Wiley, New York 1972).

18 Hamosh, M.; Clary, T.R.; Chernick, S.S., and Scow, R.O.: Lipoprotein lipase activity in adipose tissue and mammary tissue and plasma triglyceride in pregnant and lactating rats. Biochim. biophys. Acta *210:* 473–482 (1970).

19 Hamosh, H.; Simon, M.R.; Canter, H., Jr., and Hamosh, P.: Lipoprotein lipase activity and blood triglyceride levels in fetal and newborn rats. Pediat. Res. *12:* 1132–1136 (1978).

20 Hardell, L.I. and Carlson, L.A.: Concentration and composition of human serum lipoproteins at birth. Clinica chim. Acta *90:* 285–294 (1978).

21 Herrera, E. and Knopp, R.H.: Pentose monophosphate shunt dehydrogenases and fatty acid synthesis in late rat pregnancy. Experientia *28:* 646–647 (1972).

22 Herrera, E.; Knopp, R.H., and Freinkel, N.: Carbohydrate metabolism in pregnancy. VI. Plasma fuels, insulin, liver composition, gluconeogenesis, and nitrogen metabolism in the fed and fasted rat. J. clin. Invest. *48:* 2260–2272 (1969).

23 Hummel, L.; Schwartze, A.; Schirreister, W., and Wagner, H.: Maternal plasma triglycerides as a source of fetal fatty acids. Acta biol. med. germ. *35:* 1635–1641 (1976).

24 Knopp, R.H.; Boroush, M.A., and O'Sullivan, J.B.: Lipid metabolism in pregnancy. II. Postheparin lipolytic activity and hypertriglyceridemia in the pregnant rat. Metabolism *24:* 481–493 (1975).

25 Korez, Z. and Shafrir, E.: Placental transfer of free fatty acids in the pregnant rat. Proc. Soc. exp. Biol. Med. *116:* 411–414 (1964).

26 Lowry, O.H.; Rosebrough, N.J.; Farr, A.L., and Randall, R.J.: Protein measurement with the Folin phenol reagent. J. biol. Chem. *193:* 265–275 (1951).

27 Llobera, M. and Herrera, E.: Lipoprotein lipase activity in liver of the rat fetus. Biochem. biophys. Res. Commun. *91:* 272 277 (1979).

28 Montes, A.; Humphrev, J.; Knopp, R.H., and Childs, M.T.: Lipid metabolism in pregnancy. VI. Lipoprotein composition and hepatic lipids in the fed pregnant rat. Endocrinology *103:* 1031–1038 (1978).

29 Otaway, S. and Robinson, D.S.: The significance of changes in tissue clearing factor lipase activity in relation to the lipaemia of pregnancy. Biochem. J. *106:* 677–682 (1968).

30 Parwaresch, M.R. and Radzum, H.: Lack of very low density lipoprotein in cord blood. Clinica chim. Acta *83:* 295–296 (1978).
31 Robertson, A.; Sprecher, H., and Wilcox, J.: Free fatty acid patterns of human maternal plasma, perfused placenta and umbilical cord plasma. Nature, Lond. *217:* 378–379 (1968).
32 Scow, R.O.; Chernick, S.S., and Brinley, M.S.: Hyperlipidemia and ketosis in the pregnant rat. Am. J. Physiol. *206:* 796–804 (1964).
33 Scow, R.O.; Chernick, S.S., and Smith, B.B.: Ketosis in the rat fetus. Proc. Soc. exp. Biol. Med. *98:* 833–835 (1958).
34 Shambough, G.E., III; Koehler, R.R., and Yokoo, H.: Fetal fuels. III. Ketone utilization by fetal hepatocyte. Am. J. Physiol. *235:* E330–E337 (1978).
35 Schwenk, E. and Joachim, E.: Biosynthesis of cholesterol. XI. Biosynthesis of cholesterol and fatty acids in pregnant rats. Proc. Soc. exp. Biol. Med. *108:* 665–671 (1961).
36 Winkler, L.; Schlag, B., and Goetze, E.: Concentration and composition of the lipoprotein classes in human umbilical cord serum. Clinica chim. Acta *76:* 187–191 (1977).

Prof. E. Herrera, Servicio de Bioquimica, Departamento de Investigación, Centro Ramón y Cajal, Crtra. Colmenar Km 9, Madrid-34 (Spain)

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Maternal Nutrient Storage and Efficiency in Production of Fetal Brain Tissue in Rats[1]

Stephen Zamenhof

Department of Microbiology and Immunology, Mental Retardation Research Center, and Brain Research Institute, University of California School of Medicine, Los Angeles, Calif.

Key Words. Maternal efficiency · Efficiency, maternal · Production of fetal brain tissue · Nutrient storage, maternal · Brain tissue, rats · Fetal brain

Abstract. Maternal 'efficiencies' in production of fetal tissue, especially brain tissue, were studied in controls and in chronically (9 generations) undernourished rats. These 'efficiencies' were formulated as the ratio of a neonatal parameter (body weight, brain weight, DNA, or protein) to the food consumed during pregnancy. Mean or total values (for the entire litter) of the above parameters were used in computation of the above ratios. It was found that all these ratios were highly significantly lower for control animals than for undernourished. The gain in maternal body weight (postpartum versus day 0 of pregnancy), i.e., nutrient storage, was found to be significantly lower or even negative in the undernourished group, but increased through generations. We interpret these results as follows. Undernourished animals mobilize their nutrient reserves, avoid deamination of essential amino acids, and improve their intestinal absorption of nutrients; thus, they are more efficient than normal animals, even though the latter may produce more fetal tissue. These improvements suggest inducible enzymes. Individual mothers in each group vary considerably in their efficiency; the most efficient undernourished mothers may produce offspring that escape undernutrition, or, in the control group, offspring with outstanding values of brain and body parameters.

Introduction

In the previous work (16) we have studied the occurrence of rats with outstanding high values (more than 2 SD above the mean) of their neonatal parameters: body weight, brain weight, brain DNA and brain protein. Many of these newborns come from 'outstanding litters' (parameter values more than 2 SE above the mean). Some of the causes of such occurrences may reside in these individual fetuses themselves (their better genetic potential, better placental transfer, etc),.), but some must reside in their mothers (especially in cases of outstanding litters).

[1] A short abstract of this work has appeared (12).