Intestinal Absorption of Glucose, and Blood Glucose and Hematocrit in Pregnant and Nonpregnant Hamsters[1] (35041)

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The hamster, *Mesocricetus auratus*, is widely used in studies of intestinal absorption and active transport (1–3) and has served in investigations of the effects of drugs (4) and environment (5) on intestinal absorption. During the course of experimentation it became increasingly obvious that little is known about the physiology of intestinal absorption in the female hamster.

Pregnancy and lactation are both "normal" conditions which are characterized by a variety of endocrinologic and morphologic changes. In the lactating rat increased cell proliferation in the intestinal crypts (6) and intestinal hypertrophy (7, 8) exemplify the adaptability of the intestine. Recently, Larralde *et al.* (9) reported increased intestinal active transport of glucose in pregnant rats. The highly utilized sugar, glucose, serves as an excellent compound to identify intestinal modification in meeting homeostatic demands.

The objective of our study was to measure the functional alteration in the intestinal absorption of D-glucose and to relate differences in physiologic modifications relevant to pregnancy.

Materials and Methods. Female hamsters, *Mesocricetus auratus*, in late stages of pregnancy and during various postpartum periods were used as experimental subjects. For comparison, two types of controls were used: virgin females, 2–3 months old, and older nonpregnant breeders. The latter had each produced several litters and were from 10–16 months old. The experimental animals were approximately 1 year old.

The hamsters were from a closed colony established in this laboratory in fall, 1966. They were maintained in transparent plastic cages (Maryland Plastics) with cedar shavings for bedding and given an *ad libitum* diet of Wayne Lab Blox and water, and a weekly supplement of fresh lettuce. Each animal was fasted for 24 hr prior to experimentation and, at the same time, young were also removed in the case of postpartum lactating subjects.

The control and experimental groups consisted of the following:

(A) virgin females, 88–113 g; (B) nonpregnant breeders, 117–151 g; (C) pregnant, near term (last 7 days), 113–182 g; (D) postpartum, 1 day, 109–128 g; (E) postpartum, 2–3 days, 94–141 g; (F) postpartum, 4–5 days, 96–134 g; (G) postpartum, 10–12 days, 89–152 g; (H) postweaning, 33 days, 110–111 g.

Glucose absorption was measured using isolated (ligated) segments of jejunum and ileum. Ether anesthesia was used during operative produres. A solution of 100 mg/100 ml D-glucose in a known volume (1 ml) of Krebs–Ringer bicarbonate solution was introduced into ligated segments each about 6 cm long. After 30 min, the solution was removed from the lumen of each segment and the concentration of glucose determined. The difference in amount of glucose indicated the amount absorbed *in vivo*. The method has been described in detail (10).

In many of the control and experimental subjects, two ancillary hematologic studies were done: hematocrits and whole blood glu-

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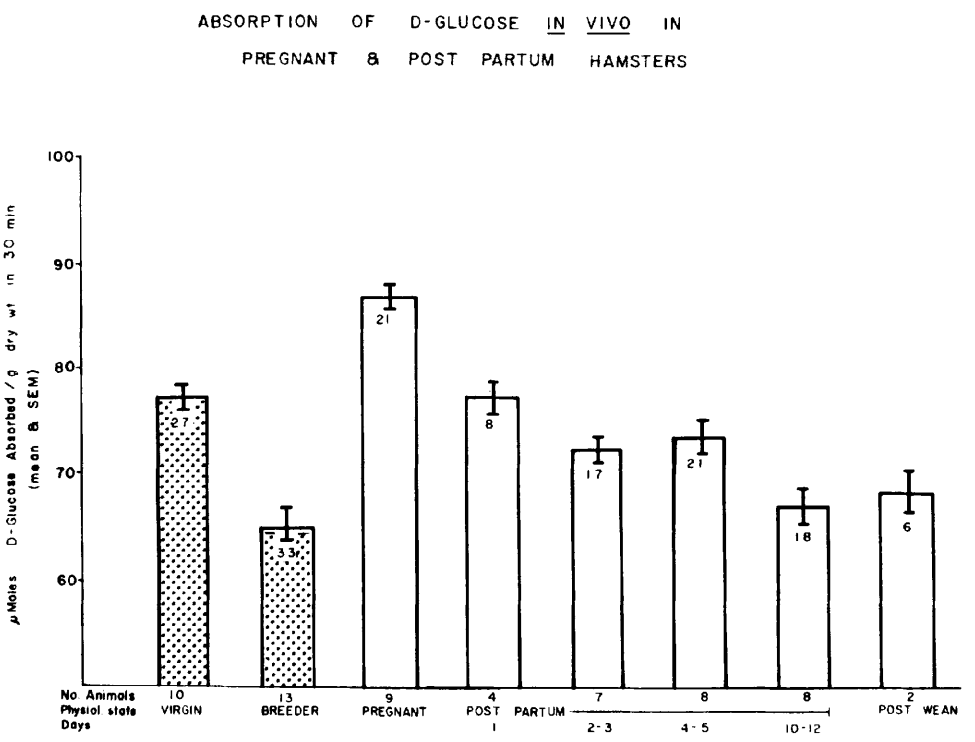

FIG. 1. The number of intestinal segments is included at the top of each column. Stippled bars indicate segments from nonpregnant females.

cose levels. Blood for both tests was obtained from the heart (right ventricle puncture) with heparinized syringe immediately after the 30 min period required for the intestinal absorption procedures.

Glucose in intestinal fluid and whole blood was determined by an enzymatic glucose oxidase method using Glucostat (Worthington Biochemical Corporation, Freehold, N.J.) and hematocrits were done by microcapillary techniques (International Micro-centrifuge, 11,500 rpm/5 min).

Results and Discussion. It was evident that glucose absorption was highest during pregnancy, and after pregnancy there was a subsequent reduction (Fig. 1). The values for virgin females and for 1-day postpartum subjects were comparable: respectively, 76.99 ± 2.43 and 76.65 ± 4.43 μmoles D-glucose absorbed/g dry wt in 30 min. A marked reduction in absorption occurred in the 10-12-day postpartum hamsters, and after weaning the level of absorption remained low. One animal, 18 days postpartum not originally scheduled for this experimental population, showed levels of 60.1 and 77.5 μmoles glucose absorbed in jejunum and ileum, respectively. The values were comparable to others in postpartum hamsters (data were not included in Fig. 1). Student *t* test comparisons were made and summarized where significant differences occurred (Table I).

Compared to the old breeders, which were found to have the lowest levels of intestinal glucose absorption, absorption in pregnant and lactating animals was for the most part greater and not unlike the levels found in virgin animals.

It seems a reasonable speculation that with pregnancy the intestine adjusts to increased nutritional demands. Larralde *et al.* (9) also suggested that the intestine adapts in response to the physiologic modifications imposed by pregnancy. Our findings with the hamster compare favorably with their results and conclusions obtained with rats.

TABLE I. Statistical Comparisons of Intestinal Absorption Between Groups of Hamsters.

Group comparisons	Probability (p values)
Virgins and old breeders	$<.001$
Virgins and pregnant	$<.025$
Virgins and postpartum (10–12 days)	$<.01$
Old breeders and pregnant	$<.001$
Old breeders and postpartum (1 day)	$<.005$
Old breeders and postpartum (2–3 days)	$<.02$
Old breeders and postpartum (4–5 days)	$<.005$
Pregnant and postpartum (2–3 days)	$<.01$
Pregnant and postpartum (4–5 days)	$<.005$
Pregnant and postpartum (10–12 days)	$<.001$
Pregnant and postpartum weaning	$<.025$

Using a similar *in vivo* technique, Musacchia and Bramante (10) obtained values for nonpregnant hamsters 2–3 months old (85–120 g) which were comparable with those for the virgin group, *circa* 70–85 μmoles and 76.99 μmoles, respectively.

Blood glucose values are summarized in Table II and, in general, the levels were inversely related to the levels of glucose absorbed. Thus, in pregnant hamsters, although glucose absorption was highest, the blood glucose level was lowest. In comparison with the other experimental groups, blood glucose values in pregnant hamsters were significantly lower ($p<.001$–$.005$). Comparable findings were reported by Amano (11) in the pregnant rat. This author reported a decrease in blood glucose levels starting on day 10 of gestation, and after delivery the blood glucose level was 13.9% higher than before pregnancy.

The low blood glucose level in pregnant hamsters may well be a reflection of the energy requirements of pregnancy, and the high level of absorption is suggested as a mechanism operating in maintenance of physiologic homeostasis.

The marked reduction in hematocrit values in pregnant hamsters and during early postpartum periods indicates the occurrence of hemodilution (Table II). This is a transient feature which apparently reverses itself when lactation is well established, for example in the 4- to 5 and 10- to 12-days postpartum animals. Furthermore, the hematocrit values for postweaning animals indicates a tendency to hemoconcentration. Reductions in hematocrit have long been known in human pregnancy. For example, Roth *et al.* (12) reported a drop in hematocrit from 39.5 to 36.7%, although these authors did not suggest that this is necessarily hemodilution.

In a separate study, hematocrit values for 12 nonoperated female hamsters were 46.7 $\pm$ 0.64. These compare favorably with the data from nonpregnant and late postpartum subjects (Table II).

Our data for nonpregnant and nonoperated

TABLE II. Blood Glucose and Hematocrit Values in Female Hamsters.

Animal conditions	Blood glucose		Hematocrit	
	No. animals	mg/100 ml	No. animals	% Packed cell volume
Experimental subjects[a]				
Virgins	4	132.0 $\pm$ 19.4	10	50.3 $\pm$ 1.6
Old breeders	10	154.8 $\pm$ 8.5	12	48.8 $\pm$ 1.2
Pregnant	5	57.0 $\pm$ 4.4	9	34.5 $\pm$ 1.3
Postpartum				
1–3 days	5	135.8 $\pm$ 18.5	11	41.5 $\pm$ 2.2
4–5 days	3	139.3 $\pm$ 19.2	8	48.2 $\pm$ 2.6
10–12 days	8	149.8 $\pm$ 19.5	8	50.7 $\pm$ 1.7
Postweaning	2	190.0 $\pm$ 11.0	2	61.5 $\pm$ 2.5
Nonoperated[b]	—	—	12	46.7 $\pm$ 0.64

[a] Blood taken after 30 min intestinal absorption procedures.
[b] Blood taken from undisturbed "normal" animals.

animals are similar to those obtained earlier by Stewart *et al.* (13). They used "Smith tubes" and reported that packed cell volumes for 5- to 8-month-old females were 48.1 ± 2.2 (SD).

Summary. Differences in intestinal absorption of glucose were evident in pregnant and nonpregnant hamsters. Glucose absorption was highest during pregnancy, diminished during lactation, and, at late postpartum and postweaning stages, the levels were comparable to those found in older breeders. The blood glucose level was lowest in pregnant hamsters. In general, there was an inverse relationship between blood glucose concentrations and amounts of glucose absorbed. Hematocrits tended to be reduced during pregnancy and 1–3 days postpartum and a reversal occurred during later stages of lactation and postweaning. The overall results of intestinal absorption of glucose, the blood glucose, and hematocrit changes conformed to reports for the rat.

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