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# Effects of Early Nutrition After Birth on the Development of Small Intestine and Body Growth in Rats with Intrauterine Growth Retardation

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**Abstract: Objective** To study the effect of early nutrition on the development of physique and small intestine in rats with intrauterine growth retardation (IUGR). **Methods** Eight normal pubs fed with normal protein diet (20%) were used as normal controls. The IUGR pups were assigned into normal protein diet group (IC group), low-protein diet group (IL group) and high protein diet group (IH group). On the 1st, 21st and 28th day after birth respectively, the weight and length of small intestine (SI), the body weight and length, and the activities of disaccharidase were measured. **Results** The body weight and length, weight and length of SI in rats with IUGR at birth were all significantly lower than those in normal rats ($P < 0.05$). Body length, body weight, length and weight of SI in IL group were all lower than those in IC, IH and normal control groups in the first 4 weeks after birth. The physique and small intestine in IH group caught up growth quickly, the body weight in the 4th week reached the normal value. In the third week, the lactase activity in IL and IH groups were higher than that in normal control group ($P < 0.05$). In the 4th week, the sucrase activity in IL group was lower than that in normal control ($P < 0.05$). **Conclusions** Early nutrition after birth has an important effect on the development of physique and SI in rats with IUGR.

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**Key words:** Intrauterine growth retardation; Nutrition; Small intestine; Growth-development; Disaccharidase; Rats

## 早期营养干预对宫内生长迟缓大鼠小肠发育及体格生长的影响

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[**摘 要**] **目的** 了解出生后早期营养干预对宫内生长迟缓(IUGR)大鼠体格、小肠发育的影响。**方法** 生后 4 周内每周分别测量正常大鼠正常饮食组(CC),IUGR 正常饮食组(IC)、低蛋白饮食组(IL)及高蛋白饮食组(IH)大鼠体重、身长。并于出生时及第 3,4 周测量其小肠长度、重量及肠粘膜双糖酶(乳糖酶、麦芽糖酶、蔗糖酶)活力。**结果** ①IUGR 鼠出生时体重、身长、小肠长度及重量均显著小于正常鼠($P < 0.05$);乳糖酶、麦芽糖酶活力高于正常组($P < 0.05$)。②IL 组身长、体重、小肠重量及长度生后初 4 周均落后于 CC,IC 和 IH 组($P < 0.05$);IH 组体格、小肠追赶生长迅速,4 周时体重与 CC 组比较差异无显著性($P > 0.05$)。③3 周时 IL,IH 组乳糖酶活力高于 CC 组($P < 0.05$);4 周时 IL 组蔗糖酶活力小于 CC 组($P < 0.05$)。**结论** 生后早期营养干预对 IUGR 大鼠早期体格追赶生长、小肠发育有重要的影响。 [**中国当代儿科杂志,2003, 5(3): 197-200**]

[**关 键 词**] 宫内生长迟缓;营养;小肠;生长发育;双糖酶;大鼠

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Intrauterine growth retardation (IUGR) has been shown to be associated with low birth weight and poor development of gastrointestinal tract. It's not certain whether different levels of early nutrition after birth have any effects on the postnatal development of body and gastrointestinal tract in IUGR. In

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the present study, we investigated the body weight, length, length and weight of the small intestine (SI), activities of disacchardase. We fed the rats of IUGR with different levels of protein diet to explore the effects of early-period nutrition on the development of body and SI.

## Materials and methods

### Animals and grouping

We developed an IUGR rat model by nutritional restriction during pregnancy. All pups were delivered by vaginal delivery. IUGR pups were assigned randomly into 3 groups: control group (IC group, n = 8) which was fed with normal protein diet (20 %), low-protein group (IL group, n = 8) which was fed with low protein diet (10 %) in the first 4 weeks of life, and high-protein group (IH group, n = 8) which was fed with high protein diet (30 %) in the first 4 weeks of life. Eight normal pups fed with normal protein diet (20 %) were used as normal control.

### Methods

The body weight and length of all groups were measured at birth, in the 3rd week (the 21st day) and the 4th week (the 28th day). The rats in each group were killed after fasting for 10-12 hours, the small intestine was carefully resected. The weight and length of each specimen was immediately measured. About 10 cm of the proximal small intestine was retained, its mucosa was removed by gentle scraping and weighted. Then the mucosa was preserved at - 70 ℃. The disaccharidase activity was measured according to the method which was provided by the article (The measurement of the mucosa disccharidases of the brusher border of small intestine, 1987, WANG Rong-Jin)

### Statistics analysis

SPSS 10.0 statistical software was used. Mean ± standard deviation was used to present normally distributed data. Student's *t* test and one way ANOVA were used to analyze the data.

## Results

In IUGR rats at birth, the body weight and length, the weight and length of SI were significantly smaller than those in normal control ($P < 0.05$). The activities of lactase and maltase of SI were higher than those in normal control ($P < 0.05$), while the surcrase activity was similar to that of normal control ($P > 0.05$). See Table 1.

**Table 1** Comparisons of the body weight, length, the weight and length of SI, disaccharidase activities between normal and IUGR rats at birth (n = 8, $\bar{x} \pm s$)

| Groups | weight (g) | length (cm) | weight of SI (g) | length of SI (cm) | lactase activity μmol/min/g | maltase activity μmol/min/g | surcrase activity μmol/min/g |
|---|---|---|---|---|---|---|---|
| Normal control | 6.01 ± 0.55 | 6.26 ± 0.44 | 0.10 ± 0.02 | 21.78 ± 2.71 | 314.8 ± 19.1 | 58.4 ± 20.5 | 13.2 ± 6.40 |
| IUGR | 4.50 ± 0.41[a] | 5.96 ± 0.40[a] | 0.05 ± 0.01[a] | 15.93 ± 2.79[a] | 382.8 ± 39.2[a] | 269.4 ± 16.8[a] | 14.9 ± 8.4 |

Note: a vs control $P < 0.05$

In the 3rd week, the body weight, length, weight and length of SI were significantly lower in IL and IC groups than those in normal control ($P < 0.05$). Those in IL group were significantly lower than in IC and IH groups ($P < 0.05$). The weight in IH group didn't show significant difference compared with that in normal control ($P > 0.05$), while the body length, weight and length of SI were significantly lower than those in normal control ($P < 0.05$). There was no significant difference in the weight and length of SI, body length between IH and IC groups ($P > 0.05$). The lactase activity in IL and IH groups was higher than that in normal control. The surcrase activity in IC group was higher than that in IH group. The maltase activity in IL group was lower than that in IC group ($P < 0.05$). In IH group, it was lower than that in normal control, IC and IL groups ($P < 0.05$). See Table 2.

In the 4th week, the body weight, length and the weight of SI in IC group were significantly lower

than those in normal control ( $P < 0.05$). The body weight, length, the weight and length of SI in IL group were lower than those in IC, IH and normal control ( $P < 0.05$), but in IH group they were not significantly different from those in normal control ( $P > 0.05$). The lactase activity was similar in all groups ( $P > 0.05$). The activities of maltase and sucrase were significantly lower in IL group than those in IC group and normal control. Maltase activity in IH group was lower than those in IC group and normal control. See Table 3.

The weight and length of SI on the 3rd and 4th week were positive relative to the body weight respectively ( $r = 0.98$, $P < 0.05$; $r = 0.91$, $P < 0.05$). The weight and length of SI were positive correlated to the body length respectively ( $r = 0.97$, $P < 0.05$; $r = 0.95$, $P < 0.05$).

**Table 2** Comparisons of the body weight, length, the weight and length of SI, disaccharidase activities among all the groups in the third week ($n = 8$, $\bar{x} \pm s$)

| Groups | weight (g) | length (cm) | weight of SI (g) | length of SI (cm) | lactase activity μmol/min/g | sucrase activity μmol/min/g | maltase activity μmol/min/g |
|---|---|---|---|---|---|---|---|
| Normal control | 44.65 ±5.36 | 19.99 ±1.30 | 1.06 ±0.13 | 68.57 ±1.94 | 184.3 ±38.7 | 233.4 ±47.4 | 733.1 ±102.9 |
| IC | 34.65 ±6.44[a] | 17.23 ±1.97[a] | 0.96 ±0.05[a] | 64.34 ±1.34[a] | 117.7 ±16.5[a] | 245.2 ±27.3 | 948.6 ±111.3[a] |
| IL | 18.33 ±3.07[a,b] | 14.00 ±0.81[a,b] | 0.38 ±0.05[a,b] | 49.04 ±3.01[a,b] | 315.2 ±58.0[a,b] | 212.2 ±72.7 | 696.8 ±91.1[b] |
| IH | 40.14 ±11.03[b,c] | 18.08 ±1.10[a,c] | 0.82 ±0.11[a,c] | 64.45 ±3.65[a,c] | 256.4 ±58.0[a,b] | 176.8 ±10.6[b] | 405.4 ±48.2[a,b,c] |

Note: a vs normal control $P < 0.05$; b vs IC group $P < 0.05$; c vs IL group $P < 0.05$

**Table 3** Comparisons of the body weight, length, the weight and length of SI, disaccharidase activities among all the groups in the fourth week ($n = 8$, $\bar{x} \pm s$)

| Groups | weight (g) | length (cm) | weight of SI (g) | length of SI (cm) | lactase activity μmol/min/g | surcrase activity μmol/min/g | maltase activity μmol/min/g |
|---|---|---|---|---|---|---|---|
| Normal controls | 60.80 ±9.47 | 23.10 ±1.42 | 2.24 ±0.22 | 74.77 ±9.06 | 53.5 ±14.9 | 258.4 ±27.5 | 751.7 ±102.0 |
| IC | 52.00 ±10.91[a] | 21.02 ±2.5[a] | 1.44 ±0.25[a] | 70.25 ±3.39 | 38.8 ±14.4 | 254.2 ±22.7 | 797.2 ±95.3 |
| IL | 21.41 ±3.54[a,b] | 15.96 ±1.29[a,b] | 0.82 ±0.41[a,b] | 53.95 ±3.08[a,b] | 66.4 ±22.4 | 137.8 ±31.5[a,b] | 343.6 ±33.2[a,b] |
| IH | 70.00 ±4.5[b,c] | 23.61 ±0.49[b,c] | 1.91 ±0.16[c] | 80.67 ±9.47[c] | 62.4 ±7.9 | 229.9 ±21.2[c] | 368.0 ±26.5[a,b] |

Note: a vs normal control $P < 0.05$; b vs IC $P < 0.05$; c vs IL $P < 0.05$

## Discussion

Some studies suggested that the growth of intestine was due to the growth of the number of cells. Early malnutrition results in the decline of the cell number, DNA, RNA and total protein[1]. Our findings showed that the body weight and length of IUGR rats at birth were lower than those of the normal rats and were accordant with the studies of Xu[2], Bloomfield[3] and Zhangqing[4]. This indicated that IUGR rats early after birth remained with malnutrition and development retardation of the small intestine. When IUGR rats were fed with normal diet or high protein diet early after birth, the small intestine caught up growth. Secor[5] reported that the combination of nutrients could induce intestinal response. Adequate nutrition would stimulate proliferation of the small intestinal cells and make it catch up growth. Adequate nutrition will increase secretion of pancreatic-biliary, splanchnic blood flow and activity of gutneuron. It can stimulate the production of intestinal growth factors[6] and protect their activity[7]. Our study presented that at birth the activities of lactase and maltase in small intestine of IUGR rats were higher, which might be interpreted as a result of the malnutrition in uterine, while the surcrase was not affected probably owned to its late development and

being less affected by uterine malnutrition. In the third week, the lactase activities in IL and IH groups were higher than those in normal control. Gomez[8] also showed that the lactase activity was significantly higher in the rats fed with high protein diet after midgut resection compared with those fed with normal protein diet. Lactin was the major carbohydrate during sucking. The lactase activity remained high level was benefit to the absorption of the lactin. On the third week, maltase activity in IL group was lower than in IC group, which was accordant with the studies of Ihara[9]. Nichols[10] regarded that villous atrophy contribued to the decrease of activity of maltase. Why maltase activity on the third and fourth week in IH group was significantly lower than in SC group is still unknown, and needs further studies to clarify the meaning and mechanism. All these findings suggested that the disccharidase activity could be used to regulate nutrition and meet the need of the digestion of different kinds of diet.

Because of protein malnutrition during the first four weeks after birth, the body weight and length of IL group didn't catch up growth. The body weight and length in IC group presented with the phenomenon of catch-up-growth, but didn't reach the normal level on the fourth week. The body weight and length in IH group caught up growth quickly and reached the normal level on the fourth week. All these suggested that IUGR rats could receive the pleasing effect of catch-up-growth when they were fed with high protein diet.

Catch-up-growth depends on the good function and structure of gastrointestine. This study showed that catch-up-growth of body in IC and IH groups was positive related to the catch-up-growth of the weight and length of small intestine. Therefore it is necessary to give the IUGR rats appropriate nutrition to promote their small intestine catch up growth.

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