The Effect of Level of Dietary Protein on Kidney Development and Function in Growing Rats

Lee, Hyun Sook · Kim, Wha Young

Department of Food & Nutrition, Ewha Womans University

ABSTRACT

This study was performed to investigate the effect of protein intake on kidney development and function in growing rats. Forty-two male Sprague-Dawley rats of weighing 97.5 ± 1.9g were divided into 3 groups and given 5%, 15% or 50% casein diets for 6 weeks.

Body weight gain was higher in the 50% group. The kidney weight was selectively affected more by the level of dietary protein compared to the other organs.

DNA and RNA content were significantly higher in the 15% and 50% groups than in the 5% group but the differences disappeared when DNA and RNA were expressed per g of kidney weight. Protein and protein/g kidney content were increased with increasing level of protein in diet.

GFR/animal and GFR/100gB. W. were significantly higher in the 50% group compared to the 5% and 15% groups. There was no differences in PAH clearance and RBF. Osmolality was not affected by dietary protein level. BUN and urinary nitrogen excretion were increased with the increasing dietary protein level.

Although urinary Ca excretion was not significantly difference among 3 groups, the rats in the 5% group showed 30% less Ca excretion compared to the other groups.

Above results suggest that dietary protein level has a great effect on the kidney weight and GFR in growing rats. Especially the hyperfiltration enhanced by high protein diet may accelerate the kidney senescence.

KEY WORDS: dietary protein · GFR · RBF · osmolality · BUN · urinary Ca.

INTRODUCTION

The kidney is one of the most important organ to maintain body's internal homeostasis. It is, however, a vulnerable organ to be deteriorated in structure and function with advancing age\(^1\sim5\). Age-related reduced kidney function may lead to water, electrolyte, and acid-base imbalance, which is a contributing cause of the chronic diseases in late adulthood, such as renal and cardio-vascular diseases, hypertension, and diabetes mellitus\(^6\).

Growth, development, and aging of kidney are under great influence of the diet, especially protein level\(^4\sim6\). When animals are fed a high protein diet, increases in glomerular filtration rate (GFR) and in the kidney size are reported\(^7\sim9\). Also men

Accepted December 5, 1990.
Dietary Protein and Kidney Development

with a normal mixed diet have a higher GFR than vegetarians with low protein intake\(^\text{10}\).

At a normal level of Ca intake, increases in dietary protein are reflected in incremental increase in urinary Ca\(^\text{11}\). A decrease in the fractional resorption of Ca by the kidney tubule reported to be the most likely cause of the protein-induced hypercalcuiuria\(^\text{12}\).

Although the excess of protein intake becomes an issue in western societies\(^\text{4}\), sufficient protein intake is still recommended in Korea. However, some Korean families from high socioeconomic class are reported to take more protein than RDA \(^\text{13,14}\). Due to the changes of dietary patterns and economic expansion in Korea, it is expected that protein consumption would be increasing further.

Therefore, we studied the effect of different levels of dietary protein on the development and function of kidney in growing rats.

**MATERIALS AND METHODS**

Fourtty-two male rats of Sprague-Dawley strain weighing 97.5±1.9g were devided into 3 groups and given either 5% (low protein), 15% (control) or 50% cascin diets(high protein) for 6 weeks. Composition of the experimental diets are shown in Table 1. The contents of Ca and P in the diet were manipulated to be 0.6% and 0.4%, respectively. All rats were housed individually in wire bottomed cage and were allowed to eat and drink water ad. libitum.

The food intake and body weight were measured every week. Three days before the end of the experiment, all rats were placed in metabolic cage for the collection of 1-day(24 hours) urine specimen. After the experimental period, all rats were fasted for 12 hours. PAH(Para Amino Hipurate, 12.5mg/ml in 2% sodium sulfate) solution was injected subcutaneously in the lumbar region to 6 rats in each group. Fifty minutes after the injection, the rats were picked up over the funnel and the bladder drained by suprapubic pressure. Immediately following urine collection, blood was obtained by decapitation\(^\text{15}\). The rest of rats were also decapitated for blood collection and kidney, spleen, liver, and epididymal fat pad were quickly removed and weighed.

Osmolality of renal medulla and cortex were measured by osmometer(Fiske Associate, Catalog N. 110825) according to the Schmidt-Nielsen's method\(^\text{16}\). DNA and RNA contents in kidney were analyzed by Schmidt-Thanhouser's modification\(^\text{17}\) of the diphenylamine reaction. Kidney protein was assayed by the method of Lowry\(^\text{18}\), lipid by the method of Folch\(^\text{19}\), blood urea nitrogen (BUN) by the method of Berrhelot\(^\text{20}\). Urinary and plasma Ca were analyzed by Automatic Absorption Spect(Perkin Elmer CO. 2380). Urinary PAH (U\(_{\text{PAH}}\)) and plasma PAH(P\(_{\text{PAH}}\)) which obtained from urine and plasma of rats injected PAH solution were analyzed by method of Goldring\(^\text{15}\). U\(_{\text{PAH}}\), P\(_{\text{PAH}}\) and Hematocrit(Hct) were used to calculated PAH clearance(C\(_{\text{PAH}}\)) and renal blood flow(RBF), using following formulas.

\[
C_{\text{PAH}}(\text{ml/min}) = \frac{U_{\text{PAH}} \times \text{daily urine volume}}{P_{\text{PAH}}} \\
\text{RBF}(\text{ml/min}) = \frac{C_{\text{PAH}}}{1 - \text{Hct}}
\]

Urinary creatinine(Ucr) was measured by method of Folins and plasma creatinine(Pcr) by method of Folin & Wu\(^\text{21}\). Creatinine clearance(Ccr) was calculated as follows.

\[
C_{\text{Cr}}(\text{ml/min}) = \frac{U_{\text{Cr}} \times \text{daily urine volume}}{P_{\text{Cr}}}
\]

All values were presented as mean± S.E. Schüff test was used to test statistical significance.