Nutrition in Far Advanced Tuberculosis
A Preliminary Study

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This study was initiated to attack the problem of establishing nutritional balance in far advanced pulmonary tuberculous patients and to observe, if possible, whether a proper nutritional balance, in itself, could favorably deflect the downward course of these patients. It was evident that the invariably poor appetites of these patients should be the first point of investigation.

The study of appetite has developed considerable experimental work. There is evidence that the sensation of hunger is directly correlated with increased gastric tone and secretions; this was evident in the fasting experiments of Hoelzel1 and the x-ray observation of Barclay.2 Glaessner,3 in 1943, offered experimental evidence that gastric tone and secretory activity varied inversely with blood sugar volumes. Blotner,4 in 1945, found that of 70 nondiabetic adults with illnesses causing prolonged physical inactivity, 63 had blood sugar findings indicative of decreased glucose tolerance. There has been evidence that tuberculous patients have a tendency toward decreased glucose tolerance although Kramer's study of 98 tuberculous patients5 showed only 17 per cent with such a tendency.

In recent years a great deal of importance has been placed upon protein in the diet. This is especially true of the influence of protein on resistance to infection and repair of injured tissues. Cannon6 in 1943, postulated that a large protein reserve was necessary to maintain proper antibody response and the phagocytic activity of mesenchymal cells. He showed that hypoproteinemic rabbits had markedly lessened ability to produce agglutinins. Madden and Whipple7 observed in 1940 that blood protein levels directly reflected tissue protein stores. Krebs8 in 1946; carefully studied the antibody response in a girl with a low total blood protein level and an extremely low gamma globulin fraction. After a full course of immunization with typhoid vaccine, she failed to develop any antibody. The maintenance of high protein levels has

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been long recognized as necessary to rapid healing of surgical wounds and ulcers. Lund, in 1945, also observed delayed gastric emptying time and edema of surgical stomata in hypoproteinemic patients.

Vitamin studies in relation to tuberculosis have been particularly concerned with vitamins A and C. Goetz, et al., in a study of 275 tuberculous and nontuberculous patients found vitamin A deficiencies particularly in the tuberculous group, increasing in degree with the severity of the tuberculous process. They also noted a marked vitamin C deficiency in the tuberculous group. Sweaney and his associates, in 1941, also noted an unaccountable exhaustion of vitamin C in tuberculous patients, increasing with the severity of the disease. Menkin, et al., in 1934, had demonstrated an apparent action of vitamin C to stimulate fibroblasts to increase connective tissue formation.

To investigate the relationship of appetite to blood sugar levels, we selected 55 patients with far advanced pulmonary tuberculosis. All of these had progressive disease with cavitation and all except four had bilateral involvement. All had shown persistent loss of weight for two to eight months prior to this study. Forty-nine of these patients stated that, although their appetites for breakfast were fairly good, they had little or no appetite for the succeeding two meals which ordinarily are served at four hour intervals.

Six hour glucose tolerance test curves were observed in 47 of these 55 patients. Thirty-seven, or 77 per cent showed definitely abnormal curves and only seven, or 15 per cent had normal tolerance curves. The abnormal curves fell into two distinct types. Twenty-six, or 55 per cent, demonstrated a sharp blood glucose rise in the first half hour with a slow decline, not returning to the base line before three hours; this was designated as a Type I curve. Ten, or 22 per cent, showed a sharp rise continuing beyond the first hour, falling slowly and not returning to the base line until four hours after ingestion of the glucose; this curve was designated Type II. Significantly, all ten patients demonstrating Type II curves were extremely ill; four are now dead and four are terminal. Graphic representation of these glucose tolerance curves are shown in figure one.

On the premise that the poor appetite of these patients might be due to a hyperglycemia prolonged into the next meal period, a two meal diet was devised, composed of an unusually large breakfast and a supper eight hours later, interrupted only by a light noon supplemental feeding. The diet had values of approximately 3400 calories, protein 160 grams, fat 77 grams, carbohydrate 560 grams. Our normal hospital diet has approximately the same caloric value, but definitely lower value for protein.
Although these patients were for the most part on a high vitamin regimen, this experimental diet provided daily supplements of 5000 units A, B and D with 500 mg. of ascorbic acid to obviate the effect of any deficiency factor. Breakfast and supper were approximately the same in nutritional values, with each consisting of from 220 to 250 grams of carbohydrate, 60 grams of protein, and 30 grams of fat. Two hundred and fifty to 400 calories were allotted to a mid-day and an evening supplement consisting of an egg nog formula and cookies. Each patient accepting this diet was provided an intake chart with instructions to chart accurately the proportion of each food item rejected daily. After a short time on the diet it was found that the low fat content decreased the palatability of the diet, which was then changed, raising the fat content to 150 grams at the expense of carbohydrate which was reduced to 350 to 370 grams.

Only 24 of the 55 studied as to glucose tolerance would accept the rigid limitations of this diet and keep an intake chart accurately enough to study. These 24 patients recorded on an intake chart the exact proportions of each dietary item taken. Their weight trends for two months prior to the diet and for two months on the diet were tabulated, as well as toxicity evaluations, blood studies, blood protein studies and liver function tests. Nineteen of these patients had marked toxicity evidenced by fever and increased erythrocyte sedimentation rates. Eighteen had compli-
cations, including tracheo-bronchial tuberculosis, tuberculous laryngitis, pleural effusion, and genito-urinary tuberculosis. The known duration of their disease was from two to 28 years. These patients, for the most part, were so far advanced and with such extensive disease, that sanatorium care was the only possible immediate therapy. Their normal weight averaged 153 pounds; all had a downward weight trend prior to this study with an average loss per man of 21 pounds.

The 24 patients showed a total net loss of 61 pounds, or 2.5 pounds per man for the two months prior to the diet change. Following two months of the new diet they showed a total net gain of 45 pounds, or 1.9 pounds per man. The distribution of weight changes are shown in Figure two.

We attempted to correlate their intake percentage with weight trends and toxicity, as expressed by fever and increased erythrocyte sedimentation rates. It was found, by studying two week periods, that their weight gain or loss was directly proportional to food intake regardless of fever or general toxic symptoms, and that an intake of 80 per cent was the critical point above which they gained weight and below which they lost. It was noted that of 19 periods studied in patients with an intake of 80 per cent and
over, only five showed any loss of weight and of 22 periods studied in patients with an intake of less than 80 per cent, 17 showed loss of weight. At 80 per cent intake, the gains and losses were equal. The elements of food rejected amounted in carbohydrate, protein and fat to approximately the same ratio as in the total diet.

A careful computation and analysis of their intake charts disclosed that these 24 patients had averaged over the two months period on the diet, a daily intake of carbohydrates 297 grams, proteins 119 grams, and fats 120 grams. This natural selection corresponded very closely with 80 per cent of the prescribed diet, i.e., carbohydrates 297 grams, protein 128 grams, fats 120 grams. Since the average weight of these patients was 132 pounds, it might be said that the dietary components necessary to reverse the weight loss trend of this group was, per kilogram of body weight, carbohydrates 5.0 grams, proteins 2.0 grams, fats 2.0 grams. It was also noted that in selecting two week periods during which the patients had fever averaging over 99.6 degrees F, 12 of these with food intake of 80 per cent and over showed weight gain in ten periods and loss in two, one of which was associated with diarrhea. Again, in two febrile periods of two weeks duration with food intake of 80 per cent there was found neither gain nor loss of weight.

Blood protein studies before and after this high protein diet showed no essential change from those of our controls. Total blood proteins remained slightly above the low normal levels. These patients showed generally an increase in globulin and a decrease in albumin fractions, reflecting the general trend of our far advanced tuberculous patients. These fractions approached equality, but never a reversal. We could not determine that our diet influenced this trend. The hemoglobin level showed a general increase with 14 patients showing increase of hemoglobin, five decreased levels, and five maintaining a normal level before and after the diet. Nine patients showing increased hemoglobin levels were in the higher food intake group compared with five in the group with intake of under 80 per cent. Most of the patients expectorated large quantities of sputum. In order to determine if this represented a significant loss of protein, five patients were selected who produced copious amounts of mucopurulent sputa. The largest amount of protein found in any 24 hour accumulation was 1.1 gram.

**SUMMARY**

1) Decreased glucose tolerance was found in 37 of 47 patients with far advanced pulmonary tuberculosis. These patients all demonstrated poor appetites except for the breakfast meal. The
glucose tolerance curves showed prolongation of hyperglycemic levels beyond the third and fourth hours following ingestion of the glucose. On the premise that their poor appetites for the succeeding meals were due to prolonged hyperglycemia a two meal high protein diet was devised with 8 hours between meals.

2) Careful weight, food intake, and blood protein studies were made on 24 far advanced tuberculous patients on this diet. These patients showed a weight reversal from a previous average loss of 2.5 pounds per man two months prior to the diet to an average gain of 1.9 pounds per man during two months on the diet. A critical level of food intake for weight maintenance in this group was found to be 2700 calories divided into 297 grams carbohydrates, 128 grams protein and 120 grams fat. Above this level the great majority of these patients gained weight regardless of fever or other evidence of toxicity.

3) Hemoglobin levels of patients on this diet showed a general increase over the levels 2 months prior to the diet. Total blood proteins showed no essential change over those of the controls. Protein loss in the sputum was found to be negligible.

RESUMEN

1) En 37 de 47 pacientes con tuberculosis pulmonar avanzada se encontró disminución de la tolerancia a la glucosa. Todos estos pacientes tenían mal apetito excepto en el desayuno. Las curvas de la tolerancia a la glucosa revelaron prolongación de los niveles hiperglicémicos por más de tres o cuatro horas después de la ingestión de la glucosa. Sentando como premisa que sus malos apetitos en las comidas subsiguientes se debían a la prolongada hiperglicemia, se ideó una dieta alta en proteínas que consistió de dos comidas separadas por ocho horas.

2) Se llevaron a cabo estudios cuidadosos del peso, la ingestión de los alimentos y las proteínas de la sangre en 24 tuberculosos muy avanzados sometidos a esta dieta. Estos pacientes revelaron una reversión del peso de un promedio anterior de pérdida de 2.5 libras por hombre, dos meses antes de comenzar la dieta, a un promedio de aumento de 1.9 libras por hombre durante los dos meses de dieta. Se encontró que el nivel crítico de ingestión de alimentos necesario para mantener el peso en este grupo fue de 2,700 calorías, divididas en 297 gramos de carbohidratos, 128 gramos de proteínas y 120 gramos de grasas. Con dietas más altas de este nivel la gran mayoría de esos pacientes ganaron en peso, a pesar de fiebre u otros signos de toxicidad.

3) Aumentaron los niveles de la hemoglobina en los pacientes en esta dieta, comparados con los niveles de dos meses antes de la dieta. El total de las proteínas de la sangre, comparado con el
de los testigos, no mostró alteración significativa. Se encontró que fue menospreciable la pérdida de proteína en el esputo.

REFERENCES