

EXPERIENCES WITH A HIGH CARBOHYDRATE-LOW CALORIE DIET
FOR THE TREATMENT OF DIABETES MELLITUS*

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THE purpose of this report is to describe experiences with a diet of high carbohydrate-low fat content in the treatment of diabetes mellitus. These demonstrate that, providing the fat content is kept very low and the caloric value is within the minimum requirements, it is possible, in the majority of cases, to make the diet of the diabetic quite attractive even without the use of insulin. Where insulin is necessary, the dosage and frequency of administration is less than with diets ordinarily in use. A practical advantage of this form of treatment is that special articles of food, such as bran muffins, gelatines, etc., are not necessary. Two characteristic metabolic features associated with these diets are: (a) low plasma cholesterol; and (b) nitrogen retention in the early stages. These will, again, be referred to in greater detail. There is both experimental and theoretical basis for this type of diet.

Energy is available from three kinds of food, namely, carbohydrate, fat and protein. Each of these foods may be given in three different ways, that is, in normal amounts and in amounts above or below the normal. From the theory of combinations, we learn accordingly that it is possible to construct twenty-seven different types of diet with respect to their carbohydrate, fat, and protein contents. A study of the literature shows that the great majority of these have been made use of. Arguments of apparently equal force have been presented for and against both excesses and restrictions of these three different forms of foods. The literature on the subject is quite voluminous, but, as it is readily available, it is unnecessary to give a summary here. A few relevant observations may, however, be made.

In the early days of the treatment of diabetes, carbohydrate restriction was the

logical practice. It was soon discovered, however, from clinical experience alone, that a carbohydrate-free fat-protein diet invariably led to disaster. Later, Allen clearly demonstrated that dogs, when partially depancreatized to the border-line of diabetes, could readily be made diabetic by a fat-protein diet. With such a diet dogs manifest the same spontaneous downward progress observed in the human subject. In the human subject, Wilder¹ and his co-workers presented, as Lusk puts it "as clear cut a piece of metabolic artistry as may well be conceived". These workers showed that a potential diabetic can be transformed into a completely diabetic individual merely by the administration of the time honoured carbohydrate-free diet of meat and fat. This experiment also explains the production of the constant D:N ratio in the diet of Mendel and Lusk's diabetic man.² Many other such data could be referred to. The conclusion from these observations is, however, definite. Fat-protein diets from which carbohydrates are excluded find no logical place in the present day management of the diabetic.

Two experiences met with in our clinic last year may be of interest here. In both cases the histories are essentially the same. One of the patients happened to be a physician and the other a fifth year medical student. Neither sought medical attention for about a year after the discovery of the glycosuria, and in each case carbohydrate was practically excluded from the diets. When they were first seen the striking features were (a) marked weakness, (b) absence of glycosuria, (c) presence of ketonuria, (d) mild degrees of hyperglycemia in the fasting state, and (e) exceptionally high plasma cholesterol; in one case (the physician) it was 1.510, and in the other 0.980 per cent. Both of these patients were obviously heading for severe diabetes and coma. With the introduction of carbohydrates, both patients im-

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proved. In the case of the medical student it was possible to give a diet of 125 grams of carbohydrate, 130 grams of fat and 50 grams of protein without insulin; the physician required 70 units of insulin a day to maintain a diet consisting of 150 grams of carbohydrate, 140 grams of fat and 60 grams of protein. In both cases the urines are now free of sugar and acetone bodies and the blood sugars are normal in the fasting state. The student's plasma cholesterol is now normal and the physician's diet is maintained on 30 units of insulin daily and his plasma cholesterol is 0.302 per cent.

Differing from the former type of diet the effects of protein are still problematical. Protein restriction still has its adherents. Lusk,² in discussing effects of the different forms of treatment, suggests that the mere reduction of the amount of protein given to the diabetic patient may be the sole cause of the beneficial result observed. Joslin also tends towards the view that a high protein intake affects the metabolism of the diabetic adversely. Writing as late as 1927, however, Lyall³ has shown that very high protein diets appear to be undesirable only because of their potential sugar content and specific dynamic action. Protein up to two grams per kilogram of body weight apparently had no deleterious effect on sugar tolerance. On looking over our older records which, in some instances, show diets of high protein content, I found the data were unconvincing either for or against protein restriction. As none of our diets of adults have, however, contained more than about 125 grams of protein, very few can be said to have received more than two grams of protein per kilogram of body weight. However, two grams per kilogram of body weight represents more than the average consumption of protein by normal individuals.

Fat, perhaps, presents the greatest difficulty with regard to the interpretation of results. On theoretical grounds, one naturally fears large quantities of fat, as it is the incomplete utilization of this food with the resultant flooding of the body with acetone bodies which kills the diabetic. On the other hand, as Joslin puts it as late as 1928, "one cannot treat diabetes successfully without increasing the quantity of fat Even with the

most modern ideas on treatment, the statement still holds that fat forms the bulk of the diabetic patient's diet". The usual protective measures against this necessity are to give just a sufficient amount of fat to maintain body weight and to prevent ketosis. Nevertheless, workers such as Petrén⁴ and Newburgh and Marsh⁵ have given diets of very high fat proportions with apparently no harmful results. An analysis of these diets, however, shows that they were not only low in carbohydrate and protein content, but also tended to be low with regard to calories. Is it, therefore, possible that undernutrition explains the satisfactory results? As a matter of fact, the majority of the older diabetic diets which have proved successful, have, on analysis, been found to be of relatively low caloric content. Undernutrition, therefore, must have played its part.

Apropos of possible quantitative effects of undernutrition, a recent investigation by the writer⁶ may here be referred to. In an attempt to determine statistically whether insulin does or does not improve carbohydrate tolerance, it was found that the reductions of dosages of insulin in the cases studied could largely be explained on the basis of the diets (undernutrition) given.

Perhaps one of the best examples of the effects of undernutrition may be found in a diabetic met with recently (No. 1082/30). This patient contracted the disease in 1904, at the age of 37 years. He was admitted to one of the medical wards of this hospital in February of this year with cirrhosis of the liver and died of its sequelæ and not of diabetes; at the time of death the diabetes was fairly well controlled. The interesting part of his history is that since he developed diabetes in 1904 he has been on an oatmeal (van Noorden) diet. Investigation showed that though he was taking approximately 150 grams of fat daily, his diet was only about 30 per cent above his basal calorie requirements. He had led an active life. Therefore, undernutrition alone kept this diabetic alive for twenty-six years.

The above are a few brief observations which may be made and which demonstrate that our knowledge of the specific action of any particular form of food material is quite imperfect. We may now turn to a discussion of the basis of the diet under consideration, namely, a diet

of high carbohydrate-low fat content and caloric value within the minimum requirements.

The idea is not new. The literature shows that there has been a gradual tendency to increase the carbohydrate content of the diet of the diabetic. Without alteration, however, in the proportion of the other food materials, namely, fat and protein, this practice has naturally resulted in the increased use of insulin, either with regard to amount or frequency of administration.

There appear to be good reasons for the use of liberal quantities of carbohydrates. Firstly, as Joslin⁷ points out, it is more rational to tend towards than to deviate from the standard diet of healthy people; secondly, in those countries where the diet consists largely of carbohydrates, the diabetes is mild, and lastly, the diets of those diabetics who have lived long, whether they showed sugar or not, were those whose carbohydrates have never been long reduced to a very low quantity. At the New England Deaconess' Hospital⁸ on a chance day, it was found that the patients received, on an average, 125 grams of carbohydrate, 92 grams of fat and 63 grams of protein. The character of the diets in our clinic has also been gradually changing, but because of the following observation.

For a number of years, and until recently, the great majority of our diets, except in very mild diabetes, consisted of approximately 50 grams of carbohydrate, 150 grams of fat and 50 grams of protein, whether the patients did or did not require insulin. Though these diets tended to be high in fat they had two favourable attributes, namely, that (a) the fatty acid to glucose ratio was less than 2.0, and (b) they tended towards undernutrition. This probably explains our low and practically normal death rates. (Last year our actual to expected death ratio was 110 per cent of the normal and during that time there were no deaths amongst our children). In view of these satisfactory results, except for the fact that the diets were not very attractive, because of their low carbohydrate content, there was no reason to alter them. In addition to this there was, however, the following experience which led to alteration of our usual practice.

We have now, in our clinic, a large and increasing number of patients some of whom

are very mild, but definite, diabetics, and the most one can positively say about the remainder of this group, judging from their carbohydrate metabolism, is that they are potential diabetics. The entire group now includes 359 patients. In the majority of these cases, glycosuria was accidentally discovered, either during routine examination for some other physical ailment, or while applying for life assurance. As they were accumulating, an attempt was made to measure the effects of subjecting some of these persons to rigid carbohydrate restrictions combined with undernutrition. Our routine in such cases is to obtain blood sugar time curves when these patients are first seen and then again at six months' intervals, or as near to that period as was possible. In the study of these cases and for purposes of control, diets were given to one-half of the group only. The subjects were selected alternately in order to conform to random sampling. The diets consisted, on the average, of 50 grams of carbohydrate, 150 grams of fat and 50 grams of protein. Though the total number of this group of patients was 359, the data of 235 only are dealt with, as the remainder were either very irregular in their appearance at the clinic or, between visits, had their dietary habits altered. Briefly,* the findings of interest here were as follows:—

The incidence of improved carbohydrate tolerance, judged by the blood sugar time curves, was definitely greater in the treated than in the non-treated group. An interesting finding, however, was that, in spite of diets, not only was no improvement of carbohydrate tolerance noted in some of the treated cases, but a decrease was actually found. When in order to find an explanation of this phenomenon, the data were correlated, amongst other factors with body weight, it was obvious that the great majority of individuals who had not improved belonged to the normal and underweight groups.

Since, with respect to the underweight group particularly, the diets could hardly be said to have been of an undernutrition nature, the tentative conclusion drawn was that either the low

* The details of this investigation, the greater part of which are of no particular interest here, form the subject matter of a separate report.

carbohydrate or the high fat content of the diets was responsible for the decreased tolerance. In view of this observation, the diets of these patients were so altered as to relate carbohydrate content to body weight. Overweight diabetics were still given 50 grams of carbohydrate, and whether the remaining patients were given 75, 100, 125 or 150 grams depended upon the ratios of actual to expected body weights. (The expected body weights were taken from standard height-weight tables.) Subsequent blood sugar time curves showed that with the above mentioned alterations of diet alone, carbohydrate tolerance improved in the majority of cases. (It might here be observed that as a control the fat and protein contents of the diets were not altered).

The above results conform with the rather interesting observations reported recently by DuBois and his co-workers on two Arctic explorers.⁹ These explorers were normal persons; but because of exposure to abnormal diets (low carbohydrate) over a period of one year, their carbohydrate tolerance, as tested with 100 grams of glucose, corresponding to our blood sugar time curve, was found to be lowered. The curves showed a tendency to a sustained elevation in the level of the blood sugar.

These observations also conform with the present generally accepted view that, to maintain insulin production at a maximum, the individual must have a reasonable amount of sugar daily. Blood sugar time curves obtained with repeated rather than single doses of glucose are suggestive. These show that, after oral administration of glucose, when the concentration of sugar in the blood is falling, the ingestion of a second dose may result in little or no increase of blood sugars.^{10, 11} In other words, the ingestion of sugar stimulates the mechanism of its utilization.

Further suggestive are the recent observations of Soskin and Campbell,¹² which rather disturb our present conception regarding the metabolism of diabetes. These workers have shown that totally depancreatized animals, in which complete absence of islet tissue was subsequently verified by post-mortem examination, were able, in time, to retain increasing amounts of ingested sugar and the storage of sugar apparently corresponded to the phenomena observed in normal animals, as it was associated

with a definite lowering of the urinary nitrogen and diminished excretion of acetone bodies.

The final observations which led to the use of this new diet were Geyelin's experiences with human diabetes. It is his results which are really responsible for our immediate investigation of a large number of cases with this new diet. While in Montreal on a visit, Dr. Geyelin related to the writer some interesting experiences with high carbohydrate diets. The most striking was that of a girl, A. B., 14 years of age, who, in January, 1923, on a diet of 90 grams of carbohydrate, 125 grams of fat and 70 grams of protein, had glycosuria in spite of 39 units of insulin a day, and in July, 1929, on a diet of 300 grams of carbohydrate, 90 grams of fat and 80 grams of protein only 46 units were necessary to keep the urine free of sugar. During this period her body weight increased from 51 lbs. to 109¾ lbs., and her height from 4 feet, 2 inches to 5 feet, 5 inches. Before the new diet was instituted the blood cholesterol was 0.300 per cent; since then it has been as low as 0.110 per cent and has never been greater than 0.185 per cent. The urine has been sugar free since April, 1925.

An important variable to consider in the interpretation of the above results is that juvenile diabetes differs from the chronic progressive form in adults, in that carbohydrate tolerance may improve rapidly when the urines are kept free of sugar. A statistical demonstration of this fact was recently reported by the writer.¹³ Another point of special interest in this case is that the child was *not overfed*, the fat content of the diet having been reduced; the calories ranged between 1,800 and 2,300. Dr. Geyelin, however, tells me that this is a representative sample of the results of similar treatment of adults.

In view of the above experiences, an attempt was made to determine the effects of diets not only high with respect to their carbohydrate content, but of caloric values conforming to the principle of undernutrition. (The caloric values of our diets are definitely lower than those of Geyelin, in order to keep body weight slightly below average). The immediate results are rather striking and it is only to be hoped that, when continued over a period of

years, conditions will not change. The points of special interest are as follows:—

(a) The patients are satisfied. The diets, as stated before, eliminate the necessity of special articles of food (bran muffins, gelatines, etc.) which, when continued for a long period of time, become distasteful.

(b) Hyperglycæmia and glycosuria are more readily controlled, whether the patients are or are not receiving insulin. The obvious conclusion from this is that insulin patients should be able to reduce the dosages, either in amount or frequency of administration. For the time being at least, this has been the usual course noted. Undernutrition is undoubtedly playing its part here. That it is not, however, the only factor, may be observed in cases where the diets have been changed with respect to the carbohydrate and fat contents, but the caloric values have been kept constant.

(c) As reduction of the dosage with insulin depends largely upon body weight, it is interesting to note that the diets are sufficiently attractive so that when given the option of being slightly underweight or of taking insulin, the majority of our patients select the former course.

With regard to instructions to the patient, these are very simple. The diets, as in the past, are constructed in terms of units, rather than weights. The great majority of our diabetics do not use and never have used scales.* In order to avoid their use, the quantities of food allowed are visualized with the aid of paper moulds, wooden blocks, etc. Thus, 30 grams, or an ounce, of bread represents one slice and is judged by a block of wood about 3½ inches square and ½ an inch thick. (It is obvious that with the different textures of bread, weights will vary, but if the above dimensions are adhered to, textures are such as to tend to give the individual rather less than more of the carbohydrate allowed). The quantities of butter, milk, meat, etc., are

* Anyone with an elementary knowledge of the theory of statistics will appreciate that owing to the marked variability of the composition of food materials, errors due to approximating, rather than weighing, foods have very little effect. The theory tells us that when an experiment involves two or more manipulations, each of which has its own error, the final error of the experiment is not equal to the sum of the individual errors, but to the square root of the sum of the squares of the individual errors.

also visualized by unit samples. For example, a 10 gram, or 1/3 oz., portion of butter is shown by a block of wood 1 inch square and ½ an inch thick.*

THE DIET

Fat.—The fat content must be kept low. The diets contain between 50 and 55 grams of fat only and if the patient adheres to the following simple rules this amount cannot be exceeded.

(a) One egg only is allowed at breakfast.

(b) Bacon, fatty meats and fish, and cream are forbidden.

(c) The amount of butter is confined to about 10 grams at each meal.

(d) One-half a glass (about 4 oz.) of milk is allowed at each meal.

(e) The total amount of meat or fish allowed for lunch or dinner is not more than 45 grams (1½ oz.) and it must be *very lean*.

Fruits and vegetables.—Fruits and vegetables, generally classed as 5, 10 and 15 per cent, are now included in one list for two reasons:— (a) the relatively small amount of carbohydrate in the fruits and vegetables compared to the total amount allowed in the diet; and (b) the results of recent analyses of these food materials.† The number containing 15 per cent or more of carbohydrate is so small that, if the rule of varying

* Sample paper and wood moulds, as well as forms for diet may be obtained from the author.

† Recently, it has been found¹⁴ that we have been over-estimating the carbohydrate content of fruits and vegetables. In the majority of cases, diabetic patients have been credited with the ingestion of more available carbohydrates than is justified according to new analyses, thus the following:

CONTAIN PRACTICALLY NO CARBOHYDRATE; Asparagus, celery, cranberries, cress, kale, lettuce, mustard and cress, radishes, rhubarb, ripe olives and watercress.

CONTAIN LESS THAN 5 PER CENT CARBOHYDRATE; Apples (fresh or stewed), artichokes, Barcelona nuts, bilberries, blackberries, black currants, Brazil nuts, broccoli, Brussels sprouts, cabbage, cauliflower, cherries (stewed), chicory, cocoanut, cucumber, damsons, French beans, gooseberries (stewed), greengages (stewed), leeks, lemons, loganberries, marrow, melon, pine kernels, plums (stewed), red currants, runner beans, sea kale, spinach, spring onions, strawberries, swedes, tomatoes, turnips and walnuts.

CONTAIN OVER 5 PER CENT AND LESS THAN 10 PER CENT CARBOHYDRATE; Almonds, apples (raw), apricots (dried or stewed), beetroots, carrots, cherries (raw), gooseberries (raw), grapefruit, greengages (raw), horse-radish, nectarines, onions, oranges, parsnips, pears, peaches (raw), plums, pineapple and pomegranate.

CONTAIN OVER 10 PER CENT AND LESS THAN 15 PER CENT CARBOHYDRATE; Green peas, peanuts and prunes.

CONTAIN OVER 15 PER CENT CARBOHYDRATE; Banana, beans (baked), figs, haricots, potatoes and peas (dried).

the articles daily is followed, accidental ingestion of excess carbohydrates is avoided.

Bread.—The remaining part of the diet is bread and the amount the individual is allowed depends upon his caloric requirements. He may receive nine, ten, eleven, twelve or more slices of bread each day. Each slice of bread added to this diet increases it by approximately 18 grams of carbohydrate, 3 grams of protein, 0.5 of fat and 70 calories.

Bulk, if lacking, may be met with by the use of fruits and vegetables of practically no food value. (See list).

An interesting experience, unknown in the past with diabetics, is that, if the energy requirement is much greater than 1800 calories, the

diet may reach the point where the patients complain of too much bread! In this case, the different kinds of 20 per cent fruits and vegetables, such as bananas, potatoes and the breakfast cereals, etc., may be substituted for the bread.

The following form is a copy of the diet in detail as given to our patients. It will be noted that bread is the only variable article, the number of slices depending upon the caloric requirements. The possible substitutions are, also, shown. In addition to this list, each patient receives sample paper and wooden moulds of the various household measures, teaspoon, dessertspoon, cup, etc.

DIET

WARNING: The samples (paper and wood moulds) of quantities of food allowed must be carefully followed, in order to avoid the use of scales.

The following are the exact quantities of foods allowed at each meal. The use of any more bread or butter or the use of more meat or meat which is not very LEAN destroys the value of the diet.

- BREAKFAST:** One (1) orange, or one grapefruit, or one apple. (See sample size of each).
One egg.
slices (oz.) of bread. (See sample of one slice).
One portion (oz.) of butter. (See sample of one portion).
Tea or coffee One-half glassful (4 oz.) of milk.
- LUNCH:** Clear broth of any kind. (Remove FAT).
One portion (1½ oz. of very LEAN meat or fish of any kind. (See sample).
Two portions (about 3 oz.) of vegetables from list allowed.
slices (oz.) of bread.
One portion of butter as at breakfast.
One portion (3 oz.) of fruit from list allowed.
Tea or coffee
One-half glassful of milk as at breakfast.
- DINNER:** Same as lunch, substituting the various meats, fish, vegetables and fruit and take
slices (oz.) of bread.

VEGETABLES

Globe artichoke, string beans, lettuce, cucumber, spinach, asparagus, endive, sauerkraut, beet greens, dandelions, swiss chard, celery, tomatoes, Brussel sprouts, watercress, cauliflower, cabbage, radishes, leeks, stewed rhubarb, green and yellow marrow, egg plant, pumpkin, turnips, onions, horse radish, beet root.

FRUIT

Olives, grapefruit, lemons, oranges, cranberries, strawberries, blackberries, peaches, pineapple, watermelon, stewed plums, raspberries, cherries, pears, apricots, prunes, apples, canteloupe, honeydew melon, blueberries.

CONSTANT USE OF ANY ONE FRUIT OR VEGETABLE SHOULD BE AVOIDED. VARY ARTICLES DAILY.

SUBSTITUTIONS

ANY ONE OF THE FOLLOWING MAY BE SUBSTITUTED FOR ONE (1) SLICE OF BREAD:—

- Three (3) LEVEL dessertspoonsful (see sample) of UNCOOKED cream of wheat.
Three (3) LEVEL dessertspoonsful of any one of the following flours, UNCOOKED:— wheat barley, buckwheat, corn, cornmeal, oat, rice, rye.
Two (2) LEVEL dessertspoonsful of rice.
Four (4) HEAPING dessertspoonsful of oatmeal.
Two (2) HEAPING dessertspoonsful of dried beans.
Two (2) HEAPING dessertspoonsful of dried whole peas.
One (1) cupful of toasted corn flakes. (See sample size of cup).
One (1) banana. (See sample for size).
One (1) potato. " " " "
Five (5) soda biscuits. (See sample for size of each).
Four (4) teaspoonsful of orange marmalade.
Three (3) teaspoonsful of sugar.

ANY ONE OF THE FOLLOWING MAY BE SUBSTITUTED FOR ONE AND ONE-HALF SLICES OF BREAD:—

- One (1) shredded wheat.
Macaroni, eight (8) strips, each strip being eight (8") inches long.

Cereals and flour are measured UNCOOKED, in order to be certain of uniform quantities. After measuring, they are prepared as usual, as the amounts of salt and water and time of cooking, etc., do not alter their food values.

With the above instructions and with the use of our units rather than the balance, the dietetic management of the diabetic becomes very simple. Although for the purposes of investigation we have so far confined our observations to individuals upon whom we felt we could rely, there appears to be no reason for encountering any great difficulties. The only possible danger, and that which we continually stress, is the temptation to use more butter with the large amounts of bread allowed. Of course, with the addition of extra fat in any form the diet becomes not only high in carbohydrates, but also high in calories. This would obviously lead to overfeeding and possibly to its dangerous sequelæ and would demand more insulin.

EFFECTS OF DIET ON BLOOD AND URINARY SUGAR

At the time of writing there are seventeen diabetics in the hospital. One of these patients may be reasonably excluded from this discussion. She is suffering from cholangitis and septicæmia and, in the attempt to conserve the liver, is receiving large quantities of glucose and insulin. With this one exception, all of these patients are on this new diet and all of the urines are free of sugar, except for very faint traces in three cases; none has acetone bodies. In eight of these cases the blood sugars are normal in the fasting state; mild grades of hyperglycæmia (blood sugars ranging between 0.121 and 0.180 per cent) are present in seven, and in two cases

only are the blood sugars above 0.200 per cent. Insulin is being made use of in nine cases.

From the above data, this question may be raised. Is it possible to explain these satisfactory results on the basis of mild diabetes? The answer to this may be found in Table I, in which are recorded the associated conditions and complications. It will be seen that there are no uncomplicated diabetics in this group. Because of the bed situation in this hospital, we avoid, as much as possible, admitting diabetics to the wards, unless the disease is severe or is associated with some other condition which requires treatment for itself. It will be noted that there is infection with suppuration in nine cases. These include four carbuncles, a compound fracture with infection, buttock, perinephritic and breast abscesses, and an acute mastoiditis. As is well known, probably no other condition interferes with the course of diabetes and tends to neutralize the action of the insulin more than infection with suppuration. In spite of this, however, the diabetes is under control in each case. As for the remaining group, if we include the cataracts, there are six cases of cardio-vascular disease. With these conditions, as is also known, individuals do not respond to insulin as readily as the uncomplicated severe diabetic.

Are these results due to the operation of the laws of chance? This, I believe, is highly improbable. This observation is based upon successive random sampling of groups of cases of similar numbers from our records. The following observations also support the idea of causal relationship, rather than accidental association.

EFFECTS OF DIET ON BLOOD CHOLESTEROL

The determination of the cholesterol content of the blood plasma is a routine procedure in all of our cases. We look upon high blood cholesterols as indicative of disturbance of fat metabolism and the higher the blood cholesterol, the greater the disturbance and, there-

TABLE I

Associated Conditions and Complications

Hosp. No.	Condition
2227/30	Herniotomy (wound suppurating)
2374/30	Compound fracture with infection
3117/30	Carbuncle
3178/30	Carbuncle
3198/30	Cardio-vascular disease
3408/30	Abscess (perinephritic)
3477/30	Abscess (buttock)
3535/30	Gangrene
3682/30	Cholangitis
3841/30	Cataract
3870/30	Abscess (breast)
3892/30	Cerebral thrombosis
3916/30	Carbuncle
3978/30	Acute mastoiditis
3988/30	Cataract
3989/30	Carbuncle
4128/30	Gangrene

fore, the greater tendency towards complications, particularly acidosis. As infections, particularly those associated with suppuration, tend to interfere with the action of insulin, persons so affected also tend not only to have raised blood sugar but also raised cholesterol. In Table II are, therefore, given the cholesterol value of the nine cases with suppuration

TABLE II

Cholesterol Contents of Diabetic Blood Plasma in Cases of Infection with Suppuration

NEW DIET		
Hosp. No.	Condition	Cholesterol (per cent)
3978/30	Mastoiditis	0.119
3870/30	Mastitis	0.138
3117/30	Carbuncle	0.146
3916/30	Carbuncle	0.166
3989/30	Carbuncle	0.181
3477/30	Abscess (buttock)	0.107
3408/30	Abscess (perinephritis)	0.156
3178/30	Carbuncle	0.156
2374/30	Compound fracture	0.111
Average		0.142
OLD DIET		
Hosp. No.	Condition	Cholesterol (per cent)
5525/24	Carbuncle	0.208
3351/24	Carbuncle	0.222
992/25	Carbuncle	0.326
3213/25	Carbuncle	0.265
4559/26	Carbuncle	0.416
5699/26	Carbuncle	0.146
5696/27	Carbuncle	0.284
5841/29	Carbuncle	0.183
6585/29	Carbuncle	0.181
Average		0.248

previously referred to. For comparative purposes, nine other cases with suppuration (carbuncles) were selected at random from our records and their cholesterol data are recorded. It will be noted that, although normal plasma cholesterols were also associated with the older diets, in the majority of these cases, the values were high. The average plasma cholesterol of the nine cases selected at random from our records was 0.248 per cent, whereas with the new diet it is 0.142 per cent.

Parenthetically, it may be observed that the low blood cholesterol is the most striking feature of this diet. One cannot help being impressed with this fact as the dozens of analyses accumulate weekly. An observation of interest may here be made. On August 5th, Dr. Howard Root, of Joslin's clinic, visited our hospital. As Dr. Root has taken a special

interest in the blood cholesterol in diabetes, and in order to demonstrate the effects of the new diet, 16 cholesterol determinations were made on that day. The following were the results:—

Case No.	Plasma cholesterol (per cent)
1	0.157
2	0.132
3	0.222
4	0.151
5	0.185
6	0.190
7	0.189
8	0.179
9	0.169
10	0.099
11	0.159
12	0.098
13	0.208
14	0.196
15	0.137
16	0.169

Incidentally, the insulin dosage required in our hospital cases has been lower than for similar types of cases met with previously. With infection and suppuration 60, 80 and even 100 units daily have been found necessary, and, at times with control of acetonuria only, glycosuria persisted. One must hesitate to stress this observation, in view of the large number of variables which may influence insulin dosage. Some of these variables are not recognizable, while others may be recognized, but not controllable. The facts are mentioned merely in order to suggest further study of this phenomenon in the future.

It so happens that of all of the above mentioned hospital cases, three only were our own patients prior to their admission. We, therefore, have no accurate control by which to judge progress, that is, no index of their metabolism prior to their new diets. That the above data, however, are the result more of causal relationship than accidental association is further suggested from the data in Table III obtained from patients treated with insulin who have been in our clinic for some time. Their metabolism was known prior to the dietary changes made recently.

A uniform procedure was adopted in the study of these cases. Blood and urinary sugar were estimated before the new diet was instituted. Slight reductions of insulin dosage were then made, followed, again, by blood and urinary sugar analyses, in order to eliminate the possible effects of excess quantities of insulin. The new diets were then given.

TABLE III.

No.	Old Diet								New Diet							
	Diet				Insulin (units)	Urine sugar	Blood		Diet				Insulin (units)	Urine sugar	Blood	
	C.	F.	P.	Cal.			Sugar	Choles- terol	C.	F.	P.	Cal.			Sugar	Choles- terol
227/30	125	140	60	2000	10	0	0.153	0.208	236	56	72	1736	5	0	0.192	0.187
6037/29	125	140	60	2000	50	0	0.200	0.272	236	56	72	1736	40	0	0.158	0.151
5158/25	50	150	50	1750	40	0	0.222	0.370	200	56	66	1568	40	0	0.147	0.200
3954/24	50	150	50	1750	20	0	0.111	0.252	218	56	69	1652	10	0	0.122	0.244
5135/21	85	150	50	1890	40	0	0.166	0.287	218	56	69	1652	30	0	0.172	0.225
5053/28	100	140	50	1860	50	0	0.181	0.277	236	56	72	1736	40	0	0.174	0.151
1269/30	125	140	60	2000	30	0	0.129	0.138	236	56	72	1736	10	0	0.117	0.211
241/27	85	150	50	1890	50	0	0.126	0.333	218	56	69	1652	30	0	0.115	0.212
3388/27	50	150	50	1750	35	0	0.166	0.263	236	56	72	1736	40	0	0.153	0.111
2044/26	50	150	50	1750	20	tr.	0.244	0.378	236	56	72	1736	20	0	0.227	0.196

It will be observed that with the replacement of the old diets by those of slightly less caloric value but of much higher carbohydrate and much less fat content, the diabetes was controlled with the use of less insulin in seven cases. In one case only was the dose increased (No. 3387/27).

Of all the data in Table III, the blood and urine sugars are regarded as the most significant. It is generally recognized that it is possible to alter the diet of a diabetic and affect the disease adversely without alteration of the clinical picture for some time; depending upon the severity of the disease, the clinical picture may not change for weeks, months, and, in isolated cases, years. The cholesterol values may also not be affected for some time. With regard to blood sugar, however, the course is entirely different. Following a diet which affects the course of the diabetes adversely, the appearance of hyperglycemia may not only be a matter of days, but of hours. In addition to the above mentioned cases, we now have 41 other diabetics whose metabolism is known. The disease in these cases is relatively mild, as the patients require no insulin to maintain normal blood sugars and urines free of sugar. Briefly, it may here be observed, that in none of these cases when diets of 200 to 236 grams of carbohydrate, 56 grams of fat, and 66 to 72 grams of protein were substituted for their older diets of approximately 50 grams of carbohydrate, 150 grams of fat, and 50 grams of protein, do the most recent blood and urinary analyses show unfavourable progress.

It is interesting here to note that in a number of cases there was an early and temporary dis-

turbance of the blood sugar with the change in diet. This fits in with the generally recognized experiences that once the dietary habits of the diabetic have been altered the disease is not so readily controlled by new dietary changes as when diets are given in untreated cases.

In this group, also, one of the most characteristic findings is the lowering of the blood cholesterol. Whether this is due to the low fat, high carbohydrate, or low caloric factor is at the present time difficult to estimate. In the interpretation of these data one must, also, consider the fact that only one egg a day is allowed in this diet. Eggs are exceptionally high in cholesterol. (One egg contains approximately 0.40 grams of cholesterol).

NITROGEN AND RESPIRATORY METABOLISM

A characteristic metabolic feature of this new diet is nitrogen retention in the early stages. The explanation of this is not quite clear. It is suggested that it is probably due to the difficulty with which diabetics are kept in nitrogen equilibrium when on relatively high fat and low carbohydrate diets. This difficulty was first noted by Geyelin and DuBois.¹⁵ Lyall³ suggests that the attainment of nitrogen equilibrium depends upon the varying degree of ability to utilize glucose. If only a minimum quantity of sugar can be utilized the patient is thrown back on endogenous protein and fat as a source of energy. It is, therefore, suggested that this observation applies to older diabetic diets, such as our diet of 50 grams of carbohydrate, 150 grams of fat, and 50 grams of protein, since, with such diets, though the

diabetics could probably utilize a greater amount of carbohydrate they did not receive it.

The respiratory metabolism data are also of interest. A rather peculiar finding in the diabetics treated with insulin, and one repeatedly observed, was a respiratory quotient above unity within a short time after each dose of insulin, accompanied by an increased metabolism. Without the increase of metabolism, the probable explanation would be conversion of sugar to fat. If this process is natural it would appear to be uneconomical, particularly with regard to the hibernating animal. Professor Lusk, however, when shown the data, suggested that it is not quite clear that the storage of carbohydrates takes place without specific dynamic action. The respiratory metabolism data when performed daily also showed a gradual increase of the quotient in the fasting state, suggesting an increased storage of carbohydrates.

These are a few observations which may here be referred to briefly with regard to the metabolic data. The latter, in detail, form the subject matter of a separate report. The purpose of the present communication is merely to record our experiences with this new diet. They clearly demonstrate that, at least for a short time, it is possible to replace the older diets of relatively high fat-low carbohydrate with diets of high carbohydrate content and of practically iso-caloric value, not only with no disturbance of carbohydrate metabolism but apparently with improvement. This applies whether the individuals do or do not require insulin. Further experiences are, obviously, necessary in order to determine the permanency of the effects of these diets. The blood sugar, however, which is the most sensitive index of altered carbohydrate metabolism, affords much encouragement and the primary purpose of this communication is to prompt others with similarly available material to test the diet.

It must here be stressed that this diet is an undernutrition one, except that the term "undernutrition" is used in a somewhat different sense than it was prior to the advent of insulin. Before insulin, undernutrition, the

only successful method of keeping severe diabetics alive, meant keeping them on diets incompatible with comfort and food requirements for ordinary duties. The term undernutrition, as used in this report, means keeping diabetics slightly under rather than over weight, but compatible with comfort and daily duties. Individuals are kept 5 to 10 lbs. under their average body weight. It has, however, been our experience, at least so far, as stated above, that when individuals are given the option of being 10 lbs., underweight or of taking insulin, they invariably choose the former course.

In this work I am gratefully indebted to the Chiefs of the various Services of this hospital. It is because of their coöperation that the entire material of this hospital is, and always has been, available for investigation purposes by this department and affords the accumulation of large amounts of experience in very short periods of time. Acknowledgement is, also, due our dietitians, Miss Ruth Parke and her assistant, Miss Gwendolyn Taylor, for their very valuable assistance. Appreciation is due Mr. Julian C. Smith, of Montreal, and a Governor of this hospital, for his continued interest and financial assistance in the work of this department.

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