A British Medical Association Lecture ON DIABETES MELLITUS AND ITS TREATMENT BY INSULIN.

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BY
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It had been suggested to me by your secretary that my remarks this afternoon should be as practical as possible, and that they should therefore include a description of the method of performing blood sugar estimations. With the former part of the request I readily concur, and shall endeavour to steer clear of any unnecessary theoretical considerations; but that the latter part is a natural corollary for men engaged in busy practice is open to doubt. Let it be clearly recognized at the beginning that insulin has not come as an easy means of relieving the practitioner of the dietetic care of his diabetic patients. It is certainly a valuable addition to his pharmacopoeial armamentaria, but it brings with it its own claims on his attention, and it has revived an interest in the dietetic principles which are the basis of the intelligent treatment of this disease.

The generally accepted view is that in the great majority of ordinary typical cases diabetes is due to a disorder of the function of the islets of Langerhans in the pancreas, with deficiency of their internal secretion, a substance which has been called insulin. The cause of this disordered function may be found in some infection in the pancreas, or in simple atrophy, or in an alteration in the balance which normally exists between the different ductless glands. It may develop as a result of fatigue of the islets from too great a load being put on their function by over-ingestion of sugars. In some cases there may be inherent weakness in the gland, which only awaits some other factor to determine a true diabetes. Be that as it may, we have in many cases to deal with a disease which owes its origin to a lesion that is not infrequently progressive in character—a lesion for which there is at present no known means of cure in the real sense of the word, though there may be arrest or delay. Insulin is not a cure of the lesion any more than digitalis is a cure for the myocardial degeneration which makes possible a failing heart with auricular fibrillation. But just as digitalis may so relieve the heart in such a condition as to afford a respite of perhaps some years, so insulin may, if suitably employed, relieve the pancreas from fatigue and prolong life; and we hope that it may, in cases of functional derangement of the islets, so protect the overloaded organ for such a time that it may regain some at least of its lost powers.

CARBOHYDRATE METABOLISM: THE RENAL THRESHOLD.

Let us refresh our memories by reviewing some of the aspects of carbohydrate metabolism which are cognate to our subject. The pancreas has the power, by means of the secretion which it pours into the intestine by the pancreatic duct, of dealing with the digestion of carbohydrates, proteins, and fats. This secretion is not at fault in diabetes. The carbohydrates, whether starches or sugars, appear in the blood as glucose. It is of interest for us in the West of Scotland to remember that the first to point out that sugar was a normal constituent of the body and was present in the blood was Dr. Robert MacGregor of Glasgow, who in 1837 presented a thesis on this subject to the Faculty of Physicians and Surgeons. Some of the sugar remains in the blood, giving the blood a concentration of from 0.1 to 0.18 per cent. of glucose. The rest is stored as glycogen in the liver, muscles, and other parts. The combustion of sugar takes place in great part in the muscles, and the glycogen storage dépôts are

called on to supply their needs. During combustion glucose is broken up and excreted as water and carbon dioxide. What is not required may be deposited as fat. It ought to be noted that normal kidneys are impervious to sugar in the blood which is in a concentration less than 0.18 per cent. This figure is known as the normal renal threshold. If for any reason sugar in the blood rises above that figure sugar appears in the urine. Another point should be noted. Fats when consumed in the body are also broken down into water and carbon dioxide, but this only takes place completely if some carbohydrate is being consumed at the same time. If no carbohydrate, or an insufficient amount, is being consumed, then combustion of fats is not complete, and certain products of the fatty acids circulate in the blood and give rise to symptoms with which we shall have to deal later.

It would appear that the internal secretion of the pancreas—that is, the insulin—has to do with the storage of glycogen, with the combustion of sugar in the muscles, and, either directly or indirectly, with the storage of fats. In diabetes this function is inefficient. The glycogenic dépôts in the liver are found to be depleted of glycogen, combustion of sugars is interfered with, storage of fats is defective, and the combustion of fats without sufficient carbohydrate leads to an accumulation of the products of fatty acids in the blood and the presence of acetone and aceto-acetic acid. Further, in the metabolism of protein carbohydrate may be split off to the extent of as much as 58 per cent., so that in a sense there is overproduction of sugar. From all these causes sugar accumulates in the blood, and as the concentration is much above the normal renal threshold of 0.18 per cent. sugar passes into the urine. This is but a very imperfect sketch of the metabolism of carbohydrate in health and in diabetes, but it may serve as a working basis for discussing treatment. You will observe that the sugar in the urine in diabetes is due to excess of sugar in the blood—there is hyperglycaemia. Glycosuria, as we shall see when discussing blood sugar estimations, is not always associated with hyperglycaemia.

Allen's Dietetic Treatment.

Much of the modern conception of diabetes and its treatment dates from the time when Dr. F. M. Allen of Boston published, in 1914, his conclusions based on his experiments on depancreatized dogs. One or two of the facts brought out by him have a bearing on our subject, and may be referred to with profit. Removal of the greater part of the pancreas of dogs, leaving only one-tenth, causes severe diabetes and ultimately death. If a larger portion is left—say one-eighth—then the dog has diminished tolerance for carbohydrate but can subsist on a meat diet. If to this dog bread is given glycosuria appears, and if this is continued for any length of time, then on returning to a meat diet it is found that the dog now has glycosuria without any added bread. That is to say, feeding a dog on carbohydrate when it has a diminished tolerance diminishes that tolerance still further, and diabetes results. This has a definite relation to clinical cases of the disease, in so far that if too much carbohydrate is given the tolerance is reduced and the condition of the patient becomes worse. Conversely—and this was also found in dogs—by starving the patient for a time and resting the pancreas the tolerance for starchy foods is increased. He also found that the more starch you give to a normal person the more is used, while the more starchy food you give to a patient with diabetes the less is utilized.

Allen's aim was to obtain for the patient a diet which would not tax the tolerance for carbohydrate, and at the same time would be sufficient for the needs of the body. This, as we shall see, is not always possible in the more severe types of case without the production of undesirable symptoms. His method was to starve the patient in the first place in order to rest the pancreas and get the urine sugar-free, and then to give carbohydrate in the form of green vegetables and estimate the tolerance by gradually increasing the amount till sugar appeared in the urine, one starvation or partial starvation day being observed each week. Protein was given up to about the minimum

body requirements, and the remainder of the required energy or calorie value was supplied in the form of fats.

It will thus be seen that certain basal factors must be known before a diet can be properly prescribed. The food values in this connexion are stated in calories, the calorie being the amount of energy as heat required to raise 1 kilogram of water 1° C., or 1 lb. of water 4° F. A person at rest requires about 11 to 14 calories for each pound of body weight. Thus a man weighing 10 st. or 140 lb. requires from 1,500 to 2,000 calories a day. If doing light work he would require from 2,200 to 2,500 calories; 1 gram of protein or carbohydrate supplies 4 calories, and 1 gram of fat 9 calories. Diets in health vary in different grades of society and according to the amount of work to be done or the ability to pay for the best proportion. A common European diet consists of about 400 to 500 grams of carbohydrate, 120 grams of protein, and 100 grams of fat. Diabetics cannot, of course, take anything like this amount of carbohydrate, their tolerance usually being between 100 and 0. With them the first thing to do is to estimate the amount of protein required, as this cannot be obtained from other foods. Less than half a gram per pound of body weight is sufficient, or 65 grams for a 10-st. man. The carbohydrate is given up to just a little less than the patient's tolerance, and the balance of the calories is obtained from fats. If his tolerance for carbohydrate is between 50 and 100 grams there will be little difficulty in giving an efficient diet, though he may grumble at the relative want of starchy food. If the tolerance is low—say 10 to 20 grams—then it will be more difficult to give a sufficiency of fats to make up the calorie value without at the same time causing a production of acid bodies in blood and urine. Attempts have been made to fix in figures the proportion between the fat allowed and the available carbohydrate which is consumed in the body, the available carbohydrate being the actual carbohydrate *plus* about half the protein. A good working ratio is 2 to 1—that is, twice as much fat as the total available carbohydrate which is being used, not the carbohydrate that the patient happens to be getting. The amount of fat that may be used without the production of acid bodies is sometimes more than this. A patient with a tolerance of 20 grams of carbohydrate and a weight of 10 st., doing very light work and thus requiring 2,200 calories, would get 65 grams of protein, and this, with 20 grams of starch, would supply 340 calories, leaving 1,860 to be obtained from fat. This means 207 grams of fat, which is much more than twice the starch and half the protein, and he would be very liable to have some acidosis. If, on the other hand, the fats were reduced he would lose flesh and strength. It is in such a case of diabetes that insulin proves of great value, in that it can do for the carbohydrates what the patient cannot do himself. When the patient has a tolerance of from 50 to 100 grams the need for insulin is not so great.

TREATMENT BY INSULIN.

Insulin is obtained chiefly from the pancreas of the sheep or pig, and is sold as a watery solution of a more or less standard potency. Each unit of insulin is supposed to be able to deal with from 1 to 4 grams of carbohydrate, 2 being taken as an average. By its action it diminishes the amount of sugar in the blood, assists the storage of glycogen in the liver, and removes the glycosuria. It permits of the utilization of more carbohydrate, and thus fats are more completely metabolized, so that acid bodies disappear from the blood and urine, while weight is increased and the patient experiences a greater sense of well-being. This power of lowering the blood sugar constitutes its one real danger if not properly controlled. Should the blood sugar fall to a very low level or fall very rapidly certain symptoms arise which may be fraught with danger to life—the symptoms of hypoglycaemia. There is therefore a definite danger in the use of insulin, and this danger necessitates a careful diagnosis and sometimes an estimation of the blood sugar.

All cases of glycosuria are not cases of diabetes mellitus. This fact will be better understood if we follow the changes that take place in the blood sugar after the ingestion of a quantity of glucose. In an average healthy person, after

a night's rest and without food, the blood sugar may be about 0.1 per cent.; if 50 grams of glucose in water are then given it may rise in half an hour to 0.14, in another half-hour to 0.15 or 0.16, but never above 0.18 per cent., the normal renal threshold. In another half-hour it may have fallen to 0.12 or less. That is to say, the blood sugar rises within one hour after glucose to a maximum level which is less than the normal renal threshold, and is usually back to its previous level within one and a half to two hours. No sugar is passed in the urine during this time. In diabetes the curve is different.

In a woman aged 42, a moderate case, with glycosuria of two years' duration, but easily cleared by suitable diet, a single test two hours after a meal with 20 grams of starch gave a reading of only 0.116—that is, within normal limits—and there was no sugar in the urine. The result being inconclusive a glucose test was made. The fasting blood sugar was 0.101, and after 50 grams of glucose it rose in successive half-hours to 0.146, 0.32, 0.251, and at the end of two hours was still 0.246. Sugar in the urine registered 2.3 per cent.

Compared with the normal the percentage of sugar is much higher, the fall is much slower, and being above the renal threshold sugar is present in the urine. Though the actual level varies, these features are common to all cases of true diabetes. If a single test after a carbohydrate meal gives a reading above 0.18 and sugar is present in the urine it is usually indicative of true diabetes.

Another type of glycosuria demands attention. In it the blood sugar is within normal limits but sugar is present in the urine. These are cases with a low renal threshold, and the term "renal glycosuria" has been applied to them, while the name "symptomless glycosuria" suggested by Patrick indicates their main characteristic.

A man, aged 38, was sent to me because sugar was found in his urine at a life insurance examination, and the result of treatment had been unsatisfactory. He had no symptoms except that he felt listless and was losing flesh when being treated. It soon became evident that he was not a case of the ordinary type and he was sent into the Western Infirmary for investigation. Three single estimations gave the following results: blood sugar 0.05 per cent., no sugar in urine; blood sugar, 0.84 per cent., trace of sugar in urine; on ordinary ward diet without added sugar, blood sugar 0.114 per cent., urinary sugar 8 per cent. His chart showed the result after 25 grams of glucose. With a fasting level of 0.062, it rose to 0.088 in half an hour, and then fell to 0.072 and was 0.053 one and a half hours after the glucose. There was a trace of sugar in the urine. This case differs from diabetes in that the blood sugar was not above normal, the fall was rapid, but sugar was present in the urine. On ordinary diet without added sugar he gained the weight he had lost, and is now, three years later, feeling quite well though sugar is still present in the urine. (I am indebted to Dr. Adam Patrick for the blood sugar estimations).

To give a patient of this class insulin might easily lower the blood sugar to a dangerous level, and this condition must be excluded on clinical or chemical grounds before insulin is administered. Symptoms are absent, whereas cases of diabetes which require insulin have definite symptoms.

There remains one other class to which I wish to allude; an example recently came under my care.

A man, aged 33, knew of the presence of glycosuria for six years, it having been discovered during a routine examination. Recently he had some weakness in his legs and he had lost 1 st. in weight, but as he was still 22½ st. neither of these symptoms seemed to be of serious moment. He had to rise twice at night to pass urine. It had been frequently free from sugar as a result of dieting, but at other times acetone was present. In view of his great weight a lesion of the pituitary suggested itself, and in any case a blood sugar curve was indicated. A single estimation by Dr. Douglas Stevenson two hours after a meal containing 20 grams of starch gave a reading of 0.165 per cent. and sugar was present. After 50 grams of glucose it rose from a fasting level of 0.112 in successive half-hours to 0.212, 0.350, and then fell rapidly to 0.150 and 0.100 per cent. About 5 per cent. of sugar was present in the urine.

This contrasts with true diabetes in that the fall to normal was unusually rapid, and it contrasts with the normal in that it went far above the normal threshold. The explanation may be in doubt, but some have ascribed these cases to defective or delayed storage of sugar. The patient is still under observation and is being tried with small doses of insulin before a meal with 35 grams of carbohydrate.

Insulin in Diabetes.

We now turn our attention more directly to insulin in the treatment of diabetes. The question whether the case is one of true diabetes mellitus must first be determined.

In many patients with symptoms of weakness, loss of flesh, thirst, polyuria, and glycosuria the diagnosis is not really in doubt and blood sugar estimations are not necessary to confirm the diagnosis. In other cases when there are few or no symptoms a blood sugar test will distinguish between renal glycosuria and a case of mild diabetes. An isolated test after a meal may supply the information if there is sugar in the urine and the blood sugar is above the renal threshold. If it is below 0.18 it does not, however, follow that it is not diabetes as the blood may have passed its maximum at the time of the test. A curve after glucose would then be necessary.

Granted that the diagnosis is confirmed, in what cases should insulin be given? Briefly, the more severe the disease, the more necessary is the treatment and the safer is its administration. Thus in cases of coma it should be given as soon as the diagnosis is made. It used to be advised that sugar should be given after the injection, but Maclean says this is inadvisable. Twenty units should be given and repeated at intervals of two or three hours till a result is obtained. The response may be very striking.

One patient in an isolated village over 120 miles by road from Glasgow, to whom I was called in August last, had developed premonitory symptoms such as sickness, diarrhoea, and abdominal pain, the previous afternoon, and by late evening had air hunger with increasing drowsiness. When seen at noon the following day she was incoherent in speech when roused, air hunger was pronounced, and acetone was present in the urine, which was scanty and did not contain very much sugar. Twenty units of insulin were injected, followed in half an hour by 15 grams of sugar which were swallowed with difficulty. An hour later she was clearer in her mind and the air hunger was less. A second dose was given two hours after the first, and within an hour the air hunger had practically disappeared and she was quite clear mentally. She was brought to Glasgow by car the same day and had 100 units of insulin within twenty-four hours. The blood sugar next day was 0.47 per cent., and her tolerance about 10 grams of starch. She has returned to her duties as a teacher, is taking 30 units of insulin a day, and has gained 1½ st. in weight. Her tolerance was not improved and she is passing at present more sugar than can be accounted for by her diet and insulin. Without insulin she would have been dead three months ago.

The ideal in the treatment of diabetes is to keep the blood sugar low, the urine free from sugar, and to give a diet at once palatable and sufficient for the patient's needs. This can be done under ideal conditions by careful dieting, the administration of insulin, and frequent blood sugar estimations. Ordinary general practice does not fulfil all these requirements. A blood sugar test takes half an hour if the reagents are ready and requires practice if reliable results are to be obtained. A blood sugar curve after glucose takes from two to two and a half hours. By care, however, a middle course is possible between the ideal and not using insulin at all. Speaking generally, two plans are available: The patient's tolerance may be estimated by the Allen method—that is, by preliminary starvation till the urine is sugar-free, and then carbohydrate, protein, and fat are gradually increased till a minimum calorie value is obtained or till sugar or acetone appears in the urine. It must be remembered that acetone is more grave than sugar and that fats will produce acetone if insufficient carbohydrate is being burnt. The protein will be limited to about 1/2 gram per lb. of body weight, while the fat may be about twice the amount of the combined weight of carbohydrate and half the protein. The difficulty in getting a patient with a low tolerance on to a sufficient diet has been already indicated, and it is in such circumstances that insulin is of value. It will be desirable to begin by giving 5 units of insulin before the morning meal, to which 10 grams of starchy food have been added. If sugar appears in the urine the insulin should be increased a little, and then the diet and the insulin should be increased in this manner till the diet is sufficient or the patient is satisfied. The increase of the carbohydrate will, of course, allow of an increase of the fat ration. It is recommended that the insulin be given before the morning and midday meals rather than in the evening. Should symptoms of hypoglycaemia arise they are not likely to be severe if the treatment is carried out in this progressive manner, and they can readily be overcome by letting the patient have some sugar with tea, or by giving a sweet.

The other plan, which is gaining more favour recently, is

to dispense with the period of starvation and to give the patient a limited diet from the beginning. Protein is given well within the 1/2 gram per lb. of body weight; about 20 grams of starch are added and fat, in the proportion of about one and one-half of the available carbohydrate. On this diet sugar disappears from the urine in some cases, and the diet is increased gradually. If sugar persists then insulin is given in small doses till the urine becomes just sugar-free. Starch and insulin can then be increased gradually as before with addition of fat till a sufficient diet is obtained.

In either of these two methods safety is ensured by the presence of a trace of sugar in the urine at times. On the other hand there is no guarantee that the blood sugar is satisfactory, because some diabetics seem to develop a high threshold as time goes on. If the blood sugar is thus kept at a high level it is doubtful whether the pancreas is likely to improve. It will not be relieved of its load to the same extent as when the level is low. The practitioner, in the absence of blood tests, is thus between two options: either he may play for safety and keep an occasional trace of sugar in the urine, or he may keep the urine sugar-free and take the risk of hypoglycaemia. If a preparation could be produced that might be taken by the mouth without losing its potency so that it would be absorbed more slowly and its action last longer, some of the dangers that attend its hypodermic administration would at least be lessened.

Insulin has also proved to be of value in tiding the diabetic over the risk of an operation necessitating a general anaesthetic. Giving the patient insulin followed by carbohydrate has made safe what had previously been regarded with dread. It is possible that some of the symptoms ascribed to late chloroform poisoning in non-diabetics could be averted by giving the patients sugar before operation as a protection to the liver.

Symptoms of Hypoglycaemia.

A word may be said about the symptoms and treatment of hypoglycaemia. There is no level of blood sugar below which there are always symptoms and above which there is always safety. Patients have had symptoms when the blood sugar was 0.9 per cent., while others have had readings of 0.5 or even less without them. It would appear that in part symptoms are dependent on the rate of fall of the blood sugar to the low level. These symptoms may include sweating and flushing, sometimes pallor, a sense of apprehension, a tremulous feeling, hunger, a sense of fatigue, a feeling of constriction about the neck, restlessness, incoherent speech, delirium, and even coma. The milder symptoms can be quickly relieved by giving the patient some sugar in tea or allowing him some sweets. If patients are treating themselves they should be warned of the symptoms and instructed as to their treatment. If the patient is unable to swallow, a hypodermic injection of adrenaline will release glycogen from the liver to the blood. Should that fail, 50 to 100 c.cm. of a 20 per cent. sterilized glucose solution should be injected into a vein; the symptoms will then rapidly subside.

Estimation of Blood Sugar.

It may be expected that I should make some reference to the test for blood sugar. From certain advertisements of houses wishing to dispose of apparatus it might be inferred that all that is necessary is to pay the cash, accept the apparatus and reagents, and forthwith proceed to test a patient's blood. There is probably no inherent difficulty in the test that could not be overcome by a medical man who felt inclined to undertake it, but it requires time, measurements must be made with great accuracy, and the reaction has to be controlled every few days as the standard alters with time. Maclean's method is that in most frequent use, and it has the advantage that only 0.2 c.cm. of blood is required, and this can be obtained from the finger. Much practice is required before the results can be relied on, and I must leave it to others to decide whether it is a test that is likely to be a favourite with a practitioner unless he has a leaning toward laboratory methods. Personally, I do not undertake the test either in hospital or for private

patients, but invariably hand it to someone who is doing it frequently.

A blood sugar test may be necessary in some of the cases; in others it will be advisable. Some may decide to carry on without having the test done. It seems to me that it would be worth while for one of the younger or less busy practitioners in each of the two larger towns of the division to make himself efficient in it, preferably by first doing it under the supervision of some expert, and then his knowledge might, by arrangement, be made available for his fellow practitioners.

There is no quick and easy way for the treatment of diabetes. Unless some of the fundamental conceptions of the disease are appreciated it is impossible to treat it rationally. Insulin has come as a great aid, but it has not replaced the need for that close attention to diet which has been the foundation of any success that has attended treatment in the past. Added to dietetic treatment insulin has improved the outlook for the diabetic patient. It will give him a sense of well-being which he did not obtain under the older methods, it will make his diet more palatable, it will increase his physical efficiency, it may avert coma, and it will prolong life, but it is not devoid of danger, and it is not a cure for diabetes mellitus.

DIABETES AND INSULIN.*

BY

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The Provincial Board of Health, Ontario, has made arrangements to supply insulin free to physicians for patients in Ontario who are unable to pay for the drug themselves, and has issued a pamphlet which contains many valuable instructions. The following points of importance are worth noting:

1. The majority of patients suffering from diabetes do not require insulin and can better be treated by dietetic measures alone.
2. In order to decide whether insulin is necessary the patient should, wherever possible, be placed in hospital for three weeks to determine the severity of the disease.
3. The following work should be done in hospital:
 - (a) Estimation of the quantity of urine passed in twenty-four hours.
 - (b) Examination of urine and quantitative determination of sugar in urine.
 - (c) Blood sugar determinations.

The patient should then be placed on a weighed maintenance diet calculated from his basal metabolic rate, and examinations repeated daily to determine the power of carbohydrate utilization. Then if insulin be required the amount and time of the dosage should be scientifically worked out.

While in hospital the patient should be taught:

- (a) How to weigh and prepare his diet.
- (b) How to examine his urine.
- (c) The symptoms and danger signals of his disease.
- (d) How to administer insulin to himself.
- (e) The symptoms and treatment of overdose of insulin.

It is pointed out, further, that insulin is not a cure for diabetes. It is not a substitute for dietetic treatment; indeed, dietetic treatment in cases requiring insulin must be more rigidly, more carefully, enforced than in most cases requiring dietetic treatment only.

Method of Use.

The one danger to be avoided in the administration of insulin is the production of hypoglycaemia—the lowering of the blood sugar level below the normal (100 mg. per 100 c.cm.). It must never be given to any patient until it has been ascertained that there is an actual excess of sugar in the blood. Glycosuria does not in every instance mean that a person has diabetes. In the condition known as "renal glycosuria" the kidneys become abnormally pervious to sugar, so that glycosuria occurs although the blood contains less than the normal amount of sugar.

The first step in investigating a case of glycosuria, there-

fore, is to determine the amount of sugar in the blood. If the blood sugar (collected four hours or more after a meal) on an ordinary diet amounts to 200 mg. per 100 c.cm., the procedure I adopt is as follows:

Macleod's Trial Diet.¹

The patient is placed on a trial diet consisting of two parts: A, containing no carbohydrates, and B, an all-starchy part. A consists of eggs, fish, green vegetables, and fat; B of 100 grams of white bread, distributed between breakfast and dinner. This diet is continued until the glycosuria disappears or reaches a constant level. If it disappears the case is to be classified as mild, provided the blood sugar level is below 200 mg. The daily amount of bread may then be increased by 50 grams a day until sugar reappears; then three-fourths of the limit reached should be taken. A patient who can tolerate 100 grams of white bread (or 50 grams of glucose) does not need insulin, provided that the blood sugar is within normal limits when the glycosuria disappears. If 100 grams of bread cannot be tolerated the allowance must be brought down to 50 grams (or 25 grams of glucose) and if after three days the urine is not sugar-free (with normal blood sugar) the case is classified as severe and insulin may be given.

INSULIN TREATMENT.

The patient is placed on a "basal requirement diet" or the minimum diet adequate for the individual under treatment. Banting gives this as being 3/4 gram of protein per kilogram of body weight and a total of calories calculated according to the patient's height, weight, and basal metabolism. A rough estimate allows from 30 to 35 calories per kilogram of body weight.

In practice Woodyatt's² diet forms an excellent working basis; it contains 50 grams of protein and has a total value of 1,679 calories. It is adequate for a person weighing 140 lb. or 10 st. Growing children need relatively more protein than adults. Carbohydrate in the proportion of 1 gram of carbohydrate for every 1.5 grams of fat is required to enable the fat to be "burnt up." If fat is in excess in the diet ketosis occurs. Woodyatt has evolved a simple formula for regulating proportions in the diet:

Fat should equal the sum of twice the carbohydrate plus half the protein ($F. = 2C. + 0.5P.$).

This formula takes into consideration a fact not always borne in mind—that protein contains a large amount of potential glucose. The total potential glucose in a diet equals all the carbohydrate plus half the protein and one-tenth of the fat ($G. = C. + 0.5P. + 0.1F.$).

Reckoning according to these formulae, Woodyatt's basal requirement diet of 1,679 calories may be made up of: fat 139 grams, carbohydrate 57 grams, protein 50 grams. Since each gram of fat yields 9 calories and each gram of carbohydrate and of protein 4 calories, in order to calculate the number of calories in this diet we proceed as follows:

Fat	...	...	...	...	139 × 9 =	1251
Carbohydrate	...	...	...	...	57 × 4 =	228
Protein	...	...	...	...	50 × 4 =	200
Total	...	...	...	...		1679

These figures are easily remembered and from them any total number of calories can be reckoned for a smaller or larger diet. In order to reduce or increase the diet we may subtract or add gram by gram from the fat, protein, and carbohydrate until the necessary total of calories is reached. In ordering the weights we can convert grams to ounces by allowing 30 grams to 1 ounce.

The basal diet having been settled it is never reduced. Insulin is given in sufficient quantity to enable the patient to utilize the diet. It is advisable to administer the insulin in two doses a day as its effect is short lasting: one dose in the morning and another in the evening seems the best plan.

I commence with a dose of 5 units of insulin. It must be administered by hypodermic injection; by mouth it is inert. It should be given before a meal containing carbohydrate—Banting advises one hour before the meal—because carbohydrate in the food may stimulate the islet cells of the

* The substance of a paper read before the Bath and Bristol Branch of the British Medical Association.