THE FASTING TREATMENT OF DIABETES.*

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I PROPOSE to give a brief account of our experience with the fasting method at Duff House. The treatment has not been in use long enough to justify anything like a statistical analysis. I shall therefore pick out those cases which are most instructive, both as regards the results obtained and the difficulties met with.

Fasting has been used in diabetes as a means of reducing the sugar in the urine ever since it was proposed by Naunyn. It has usually, however, been prescribed with much caution, in earlier days because it seemed unlikely that it would do good to deprive the subject of a wasting disease of food, and in later days with the idea, shown to be mistaken by various workers, that because abstinence from food causes a moderate acidosis in health, it would aggravate the more severe acidosis of diabetes. But in mild types, and especially in the obese, fasting has long been found useful. I may here relate one such case, which was under treatment before Dr. Allen's work was known to me.

CASE I.—Mild Glycosuria accompanying Hypoacidity, Ileal Stasis, and Obesity. (Case 217.)

The patient, a stout man of 41, sought relief for abdominal pain and distension of three years' standing, with nausea and giddiness for the last year. He was under treatment for ten weeks. On examination the gastric juice was very poor in both acid and pepsin, the ileum, caecum, and appendix were adherent, and there was marked ileal stasis. The blood pressure was 175 mm. Hg.

The urine was found to contain 6 to 12 grams a day of sugar, but no aceto-acetic acid or acetone. The blood contained 0.17 per cent. of sugar. On a diabetic diet, continued for six days, the sugar varied from 5 to 2 grams; aceto-acetic acid and acetone appeared in the urine. Such a diet was undesirable from the point of view of the gastro-intestinal symptoms, and was not well borne.

He was therefore advised to fast, with the object of getting rid of the sugar more quickly. After one day sugar was absent. For the next six days he took a diabetic diet of 1,600 calories. He was then tested with the following foods in turn—bread, potato, oatmeal, milk, pear, apple, banana, grapes, orange, and puddings made with flour, 40 grams a day of carbohydrate being given in each case. The urine remained free from sugar, but there was still aceto-acetic acid and acetone, though never enough to estimate. The diet was increased until he was taking 112 grams of carbohydrate a day, of which 46 was in bread, 46 in puddings, 15 in stewed fruit, and 5 in milk. With this the acid bodies disappeared from the urine, which remained sugar-free.

After reading Dr. Allen's writings and becoming convinced that not only glycosuria but also acidosis was benefited by longer periods of fasting we began to make trial of the method.

Outline of the Procedure.

Fasting is continued in bed until the urine has been sugar-free for twenty-four hours, unless there is some definite contraindication, such as nausea, vomiting, insomnia, or faintness. For the first two days of the fast nothing is given except a cup of tea with 10 c.cm. of 20 per cent. cream at breakfast and tea-time. After the first two days 150 c.cm. of clear meat broth is added at lunch and dinner-time. If acidosis is present after two days of fasting, alcohol may be allowed, 0.12 gram per kilogram of body weight being given in the form of whisky four times a day—at 11 a.m., 2 p.m., 5 p.m., and 8 p.m. In the cases described below no alcohol was used. When the urine has been sugar-free for twenty-four hours, 7.5 grams of carbohydrate is added in the form of vegetables which contain low percentages of carbohydrate. On the second day of feeding 30 c.cm. of cream is allowed with each cup of tea, and three eggs are added. On the third day of feeding, and on each alternate day subsequently, 5 grams of carbohydrate is added. Vegetables containing higher and higher percentages of carbohydrate are used, and finally porridge, oatcake, macaroni, bread, and fruit. The addition of carbohydrate is continued until sugar reappears or the tolerance reaches 3 grams of carbohydrate per kilogram. At the same time 15 grams of protein in

the form of meat and fish are added daily up to 1 gram per kilogram or, in certain cases, more. When the protein has reached the desired amount, fat is added at the rate of 25 grams daily until the patient stops losing weight, or is getting 40 calories per kilogram. If sugar at any time recurs in the urine, the patient is fasted again until the urine is sugar-free for twenty-four hours. The diet is then resumed at the point where it was left off, but only half the amount of carbohydrate is given until the urine has been sugar-free for two weeks, after which the carbohydrate is increased at the rate of 5 grams per week.

The fasting part of the method is simple enough. The gradual increase of the food afterwards is not so easy, at all events in the more severe cases. Accurate diet lists and close daily supervision are required. We found that the figures given by Dr. Joslin for the carbohydrate content of the foodstuffs did not agree with those obtained in our laboratories for foods as served at table. No doubt the methods of preparation differ in different countries. My colleague, Dr. Pickering, constructed graduated tables of diet, therefore, based mainly upon the analyses of our own cooked foods, and these tables we hope to publish, as I believe they would be of use to the profession.

I will now describe five of the cases we have treated by this method, selected as representing different ages and varying degrees of severity.

In all the sugar in the urine was estimated gravimetrically, and that in the blood by Bang's method as described by S. W. Cole. With Bang's method the normal blood sugar is about 0.11 to 0.14 per cent. For beta-oxybutyric acid Kennaway's method was used, and for acetoacetic acid and acetone the Scott-Wilson method. In some cases Hurler's method was used for aceto-acetic acid alone. Ammonia was determined by Malfatti's method.

CASE II.—Mild Diabetes. (Case 331.)

The patient, a man of 67, who had done much hard and responsible work in different parts of the globe, had not felt so well for the last eight years. Loss of flesh and polyuria was noticed six months, and glycosuria three months ago. He was under treatment for six and a half weeks. On admission he complained of feeling dizzy and squeamish, and of pains and stiffness in the thighs. The arteries were moderately thickened, the blood pressure 130 mm. Hg. Moist râles were heard at the base of each lung.

The urine contained 49 grams of sugar and a trace of aceto-acetic acid. The blood contained 0.24 per cent. of sugar. On a diet containing 64 grams of carbohydrate the sugar sank to 10 grams. With a further reduction of carbohydrate to 25 grams less than a gram of sugar persisted in the urine, and the blood sugar was now reduced to 0.14 per cent., that is, to within normal limits.

On fasting the urine became free from sugar at once. Feeding was begun after two days, the amount of carbohydrate, protein, and fat being gradually increased until a total of 3,304 calories, containing 88 grams of carbohydrate, 123 grams of protein, and 261 grams of fat, was taken. The urine remained sugar-free throughout except that a trace appeared when the carbohydrate exceeded the above quantity. Aceto-acetic acid and acetone were absent and the blood sugar remained normal. All the symptoms were gone except the stiffness of the thighs, which with suitable massage improved greatly. The weight fell nearly 3½ lb.

Case 331—Analyses by A. B. Weir, B.Sc.

In all charts: TR, Trace; AA, aceto-acetic acid and acetone; O, beta-oxybutyric acid; NH, percentage of total nitrogen as ammonia; NH₃, ammonia in grams. The thickest line is the sugar, when present. The curve of the carbohydrate in the food, which sometimes crosses that of the sugar, is a thinner line.

The urine remained sugar-free throughout except that a trace appeared when the carbohydrate exceeded the above quantity. Aceto-acetic acid and acetone were absent and the blood sugar remained normal. All the symptoms were gone except the stiffness of the thighs, which with suitable massage improved greatly. The weight fell nearly 3½ lb.

This patient would probably have done well without [2894]

* A contribution to the discussion at the Royal Society of Medicine on May 16th, 1916, opened by Dr. O. F. F. Leyton.

fasting, according to earlier standards, but whereas, formerly, if sugar appeared in the urine he would have had to remain on a strict diet for a considerable time, he will now fast a day, and will then be able very soon to take again a diet containing a fair quantity of carbohydrate. In other words, he will be able to keep sugar-free with greater precision and comfort.

CASE III.—*Mild Diabetes in an Aged Man with Hypertrophied Heart and High Blood Pressure.* (Case 289.)

The patient was 79 years old. He had lived a vigorous open-air life, but had not restricted himself in any way as regards alcohol and tobacco. Thirst came on rapidly thirteen years ago, followed soon by aching and cramps in the limbs, which have persisted. He was under treatment for six and a half weeks.

He was stout, with thick arteries and an enlarged heart. The blood pressure varied from 184 to 225 mm. Hg.

The urine contained albumin varying from 0.5 to 1.5 parts per 1,000. There were traces only of acetoacetic acid and acetone. The sugar ranged from 20 to 40 grams; in ten days, on a strict diet, it sank to 8 grams.

We hesitated at first to deprive this patient of food on account of his age, and, as a tentative measure, kept him in bed one day, and allowed him two eggs only. On this day the sugar fell to 2 grams. The next three days he took a strict diet, and passed 3 to 6 grams a day. He then fasted two days, on the first of which there was a trace of sugar, on the second none. He was now very hungry, and we gave him a diet of 1,600 calories—that is, more food than the routine prescribes—with the result that a trace of sugar was present on three of the next five days, and on the other two an estimable quantity.

He therefore fasted two more days, becoming sugar-free again, and remaining so while the diet was gradually increased to 1,800 calories, including 64 grams of carbohydrate, 40 of which was in the form of white bread. A trace of sugar then appeared, but after that the urine became sugar-free without further fasting, and remained so during tests with bread, potato, oatmeal, and milk. The albumin diminished, and for the last week of his stay was below five parts per 1,000.

CASE IV.—*Diabetes in a Young Man.* (Case 301.)

The patient, aged 25, was wounded by shrapnel on active service five months before admission. During convalescence a dry mouth and thirst came on rapidly and the urine was found to contain 10 per cent. of sugar. Weakness and aching of the legs followed. He was rather thin with a clear skin.

The urine contained 174 grams of sugar, 0.8 of acetoacetic acid, and 0.1 of acetone; 6 per cent. of the total nitrogen was in the form of ammonia; 2 drachms of sodium bicarbonate rendered the urine alkaline in twenty-four hours.

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With gradual restriction of carbohydrate the sugar sank in three weeks to 20 grams a day, the acetoacetic acid increasing a little—namely, to 1.6 grams.

A fast of one day did not clear the urine, and after an interval he fasted three days, the urine becoming sugar-free on the second. The diet was then gradually increased, and the tolerance tested for measured quantities of bread, potato, oatmeal, rice, apple, banana. From these 98 to 100 per cent. of the carbohydrate was assimilated, the largest amount of carbo-

hydrate taken in one day being 71 grams. On several occasions, when the amount of carbohydrate given touched the limit of tolerance, a little sugar appeared in the urine, but was always abolished by reducing the amount in the food.

The patient went away sugar-free, the symptoms having vanished and the weight increased by 10½ lb. He and his medical adviser were provided with a scheme of diet based on the analytical results obtained.

The three preceding cases (II, III, and IV) are examples of different types. They include patients of ages ranging from 25 to 79. They show that fasting for three days, and underfeeding for several days after, did not give rise to any harmful or distressing symptoms, and led to much improvement in the feeling and condition of the patients. The urine became free from sugar and acid bodies without delay, and remained so on a more liberal diet than that taken before treatment.

I may add that repeated fasts have been used, under my direction, in diabetes complicated by phthisis, with excellent results.

In the two following cases, more severe in type, the treatment, though well borne by the patients, did not give such good results.

CASE V.—*Moderately Severe Diabetes.* (Case 337.)

The patient, aged 33, had lived in India for several years. While on active service in the Mesopotamian campaign, thirst, polyuria, and blurred vision came on suddenly, and the weight soon fell away. On examination, three months later, he was moderately thin, the pulse 112; blood pressure 164 mm. Hg.

On a diet similar to that taken before admission, which included about 80 grams of carbohydrate, the urine contained 83 grams of sugar, 2.2 of beta-oxybutyric acid and 0.6 of acetoacetic acid and acetone; 5 per cent. of the urinary nitrogen was in the form of ammonia. The blood contained 0.19 per cent. of sugar. With reduction of carbohydrate to 30 grams a day (in greens and milk), the protein in the food being kept constant, the blood sugar fell to 0.14 per cent., and that in the urine to 14 grams a day, with 1 gram of oxybutyric acid and 0.5 gram of acetoacetic acid and acetone.

He then fasted two days. There was a trace of sugar on the first day, none on the second. The blood sugar sank to 0.10 per cent. The diet was gradually raised in nine days to 2,000 calories, including 70 grams carbohydrate, without glycosuria. The acid bodies almost disappeared also, the total of the three being only 0.2 gram.

On giving more food, however, sugar appeared. A day's fast got rid of it, but it was not found possible this time to increase the food to the same extent as before, for sugar appeared and rose steadily even when no carbohydrate was taken except that in greens. Thinking that we might be giving some unsuitable form of protein we gave all the protein one day as fish and another as eggs, but the sugar continued to rise.

Ten days after the last fast the patient fasted again, this time for three days, the urine being sugar-free for the last two of them. The blood sugar was 0.12 per cent. Food was gradually added until, nineteen days after the last fasting day, a trace of sugar was found. At this time 2,200 calories, with 33 grams carbohydrate, was being taken. The blood sugar was 0.13 per cent.—that is, within normal limits.

The urine was again cleared by a two days' fast, the blood sugar falling to 0.10 per cent. The weight had now fallen 10 lb. in eight weeks, and the patient was desirous that we should spare him the long period of undernutrition and increase the food more quickly. He was then treated on former lines—that is, on a diabetic diet of sufficient heat value. The weight rose 11 lb., and the patient's sense of wellbeing and his energy rose with it, but sugar was present.

The chart (p. 843) shows well how glycosuria was postponed by making the addition of food very gradual. After the third fast it is seen that the increase of all the food-stuffs was much slower, but in each period of increasing food an estimable quantity of sugar occurred when the heat value reached the neighbourhood of 3,000 calories, which was 48 calories per kilogram. With 2,000 calories, giving 32 calories per kilogram, glycosuria was absent. The caloric value of the food—that is, the amount of protein and fat—appeared to have more effect in causing glycosuria than the amount of carbohydrate.

With the reduction in carbohydrate before the fasting the blood sugar fell to within normal limits, and the subsequent appearances of sugar in the urine were not accompanied by any obvious increase of that in the blood. But with the rise of urinary sugar at the end of the chart the blood sugar also rose. Foster suggests that glycosuria may be more difficult to control in patients without marked hyperglycaemia.

As regards acidosis, the graph shows that the first fast temporarily increased the oxybutyric acid, acetoacetic acid, acetone, and ammonia, but this effect was less with each succeeding fast.

The fall of oxybutyric acid as carbohydrate food increased after the first fast is well shown, the amount dropping nearly to zero in about ten days.

On reviewing the treatment it is possible that this patient would have done better if after the first fast a weekly fast of a single day had been given to re-establish tolerance for food, or if less fat had been given. As regards the tolerance for carbohydrate, that appeared to be lower after the later fasts than at the beginning. It got worse and not better.

It is premature to draw any conclusions adverse to the treatment from this case, for in some respects Dr. Allen's instructions were not rigorously followed. I have related the case in some detail because it was carefully observed, and because it illustrates the advantage, the difficulty, and the disadvantage of the method in a moderately acute and resistant case of diabetes.

The advantage is immediate and obvious. The urine is cleared of sugar to the satisfaction of the physician and the patient. The difficulty lies in keeping the increase of protein and carbohydrate and fat a gradual one, and at the same time resisting the natural desire of the patient to get enough to eat. The disadvantage in this case was that when the patient was on a maximum diet of, say, 2,200 calories, his capacity for work and ordinary life was greatly diminished. He did not feel fit enough to drive his car even short distances for pleasure. On a fuller strict diet, although passing some sugar, he can drive, and works a couple of hours at a book he is writing with ease and enjoyment.

Experience may show that a man lives longer if he is kept sugar-free even at the expense of his general nutrition. But, until we have evidence on that point, I am inclined to think that in treating a chronic disease it is of importance to maintain the patient in such a state of nutrition that he can work and can enjoy himself.

Case VI.—Severe Diabetes. (Case 338.)

The patient, aged 24, was on active service in France when he caught a bad cold, followed by bronchopneumonia, and was invalided home. After a month he was better, but felt run down, and on examination the urine was found to contain 9 per cent. of sugar. Before coming to us he had been kept for a time on a strict diet, and then fasted four days. The urine had become sugar-free and the diet had been gradually enlarged.

On admission he was drowsy and the breath smelt strongly of acetone. On a strict diet of 3,000 calories the urine contained 176 grams of sugar, 9 of aceto-acetic acid and acetone, and 38 grams of nitrogen. The blood contained 0.21 per cent. of sugar.

The patient's condition appeared serious, and sodium bicarbonate was given in milk up to 35 grams (1½ oz.) a day; this made the urine alkaline. A week after admission the temperature rose, and signs of bronchopneumonia developed. The acidosis became still more severe, aceto-acetic acid and acetone reaching 20 grams in the day. The urine became acid again, but was made alkaline by increasing the bicarbonate to 42 grams (1½ oz.) a day. The pneumonic signs disappeared, and in a little over two weeks after admission he was feeling well; the

aceto-acetic acid and acetone had fallen to 5 grams a day. He was still taking 35 to 42 grams of sodium bicarbonate daily. The blood sugar was now 0.17 per cent.

A week later a fast was begun. It was not complete in that for the first five days 16 oz. a day of milk was drunk, as the bicarbonate was given in milk. The fast was continued for ten days, for the last five days of which no milk was taken, but at the end of that time the urine was not free from sugar. The chart (p. 844) shows the gradual fall from 137 to 14 grams a day. The blood sugar came down to 0.14 per cent.—that is, to within normal limits.

The diacetic acid and acetone were reduced from 15 grams to 3 grams a day. Corresponding with this the bicarbonate was cut down to 7 grams (½ oz.) a day, the urine remaining alkaline. The acidosis was so much lessened that at the end of the fast no bicarbonate was needed for a fortnight, and then only half the quantity which had been needed before.

During the latter days of the fast the patient was extremely hungry and dreamed of food, but felt nevertheless better and clearer than he had for a long time. On gradually increasing the food to normal—that is, 40 calories per kilogram, without any carbohydrate except that in greens, the blood sugar rose

again to 0.21 per cent.; the glycosuria also increased, though not to its former level. The acid bodies were in much smaller quantity than they had previously been on a strict diet. The patient was up. He felt weak but was cheerful.

After an interval of nearly a month the patient undertook a second fast, which was continued for six days. This time the sugar sank to a low figure on the second day, and on the fifth there was none. A trace appeared on the sixth day, but the fast was, nevertheless, stopped, and sugar was absent on the succeeding days. Ten days after the fast he had reached 900 calories. The patient is still under treatment.

The graph shows that the percentage of blood sugar and the amount of ammonia in the urine both became normal. The oxybutyric acid, aceto-acetic acid, and acetone were also reduced rapidly to very small quantities.

I must not discuss the metabolic changes in detail to-day, but may point out that this patient was not only unable to use carbohydrate in the

food but was excreting a large quantity of sugar formed from his tissues and from the protein, and perhaps the fat in the food. Fasting had the effect of enabling him for the time being to burn all, or nearly all, of the sugar produced from his tissues. Further, as less sugar was passed out after he was fed, it had improved his capacity for burning sugar made out of protein or fat in the food, and greatly reduced his acidosis. How far the benefit will reach remains to be seen. It is certain, however, that in a case of this severity such a good effect on the disordered metabolism cannot be attained by any other means at our disposal at the present time.

It is clear, therefore, that a fast offers the quickest means of restoring, to a greater or less degree, the power of assimilating the sugar which is made in the body from the protein, and possibly the fat, of the tissues or the food. It must not be forgotten, however, that the power to use sugar made in the body may be restored in all but the most severe cases, though much more slowly, by a strict adherence to a diabetic diet. This point is of such great

Case 337.—Analyses by A. B. Weir, B.Sc.

importance, especially to those who have to go on working, that I will venture to take up your time further by giving

Case 338.—Analyses by A. B. Weir, B.Sc. M. Estimated separately March 24th to April 10th, also 17th-19th and 25th to May 2nd.

two examples of it, both in marked cases of diabetes, one with but little acidosis, and one with acidosis well established.

CASE VII.—Diabetes with Mild Acidosis treated by a Modified Strict Diet. (Case 134.)

The patient, aged 44, gave a family history of diabetes and phthisis. He worked several years in a tropical climate and had had dysentery. Nine years ago he was near to death for some weeks with an abscess in or above the liver, either dysenteric or secondary to a gangrenous appendix. After a slow recovery he remained in this country. For the past two or three years he has done hard and responsible work. Two months before admission thirst and polyuria came on suddenly and glycosuria was found.

On admission the urine contained 137 grams of sugar, 0.3 of aceto-acetic acid and a little acetone. The blood contained 0.26 per cent. of sugar. In the course of three weeks the carbohydrate in the food was diminished, and after that a strict diet was taken for a week. By cutting off carbohydrate gradually an increase of the acidosis was successfully avoided. A few grams of sugar, however, still persisted in the urine. Tests were then made to find out what carbohydrates were assimilated best; these showed very poor assimilative power except for apples. He went away at the end of two months, with about 5 grams of sugar per day in the urine. The symptoms had disappeared. There was great gain of vigour and an increase of weight of 5½ lb. The blood sugar on departure was 0.22 per cent. He was advised to keep to a strict diet, with an apple three times a week and two vegetable days a week. He did this conscientiously, with the result that the urine became sugar-free two months later and remained so.

A year after his first admission he returned to be "chemically overhauled." In the interval he had been working continuously. The urine was free from sugar. Aceto-acetic acid and acetone were present, but not enough to estimate. The blood sugar had become normal, 0.11 per cent. On adding small quantities of starches no sugar appeared, and in the course of three weeks

the carbohydrate was increased until a diet containing 81 grams carbohydrate, 96 of protein and 180 of fat was taken, yielding 2,400 calories. On this there was no sugar or acetone, and only a trace of aceto-acetic acid.

CASE VIII.—Diabetes with Marked Acidosis treated by a Modified Strict Diet. (Case 151.)

A man of 57 had had cramps in the legs for eighteen months, had lost over a stone, and felt ill. Polyuria was noticed and sugar discovered. On admission the blood pressure was 180, the liver enlarged. The urine contained 172 grams of sugar, 5 grams of aceto-acetic acid, and 0.2 gram of acetone. The blood contained 0.37 per cent. of sugar. The patient bore restriction of carbohydrate badly at first, but became accustomed to it later. The sugar did not fall, however, below 60 to 100 grams a day after three weeks on a strict diet. The aceto-acetic acid, though rising at first, settled to a level of about 2 grams a day. Tests with various carbohydrates showed that 76 per cent. of the sugar in milk was assimilated, rather less from apples, and

Case 151.—Analyses by A. J. Leigh, B.Sc.

very little from the other forms of starch and sugar tried. After two months the symptoms were almost gone, the general health much improved, and the weight heavier. There was still, however, 50 to 80 grams of sugar a day in the urine and 2 to 3 of aceto-acetic acid. The blood sugar varied from 0.30 to 0.35 per cent.

He was advised to keep three absolutely strict days a week and to take an allowance of a pint of milk and an apple on the other days.

After a year's work with careful adherence to the diet prescribed the urine is free from sugar, diacetic acid, and acetone, and the patient in good health. Small quantities of other carbohydrates are now being added to the diet.

Both these patients took food of adequate caloric value, were well nourished, and able to work steadily and efficiently, the evidence of the disease becoming less all the time. I bring them forward to show that cases which were in some respects intractable in a two months' observation did well as a result of keeping steadily to their diet, after an investigation had been made to find what food was suitable for them.

CONCLUSIONS.

Much time will be needed before a reasoned judgement on the fasting method can be given. At the present time I may summarize our observations as follows:

Fasting, up to several days, was well borne by cases of mild and severe diabetes of ages ranging from 24 to 79.

The urine was made free from sugar, the blood sugar was reduced, and acidosis greatly diminished.

All the patients felt better for the fast.

In most cases the food could be increased gradually, without glycosuria, until a more liberal diet was being taken than before treatment.

The rapid abolition of sugar had an excellent mental effect. It shortened tedious treatment, and enabled more time to be given to finding out what food should be taken and in what quantity.

The gradual increase of food after the fast calls for skilled dietetic arrangements and careful daily attention. It is not so easy as an ordinary strict diabetic diet. It is useless, however, except in the mildest cases, to increase the food quickly after the fast, as sugar returns at once.

During the gradual increase of food the patient is under-nourished. In severe cases courage and endurance are called for on his part, as it may be necessary to keep him so short of food that he is inefficient.

Regular estimation of the blood sugar should be made.

In some cases of diabetes as good an effect may be

attained, though much more slowly, without fasting and subnutrition, with its risk of depression and weakness, provided the patient is willing to keep permanently to the diet which has been found by careful testing to be suitable to his case.

At the present time the doctor, in order to decide as to the best treatment in severe cases, must judge of the temperament of the patient. To some it is purgatory to be continually having to think about tests and figures. These will do best with definite allowances in an otherwise rigid diet. In others the disadvantages of a half-starved condition must be balanced against the mental effect of the absence of sugar. We do not yet know whether the progress of the disease is arrested by this method in cases in which it would not be arrested by a permanent adherence to a rigid, though plentiful, diet.

For all milder cases, indeed for the majority of all cases, Dr. Allen's procedure offers great advantages. We have evidence enough that such patients, though not cured, may be freed from the signs and symptoms of their complaint. This beneficent result has been attained through the extraordinarily wide and painstaking researches of Dr. Allen on animals. None but those whose lot it has been to attempt to make researches and to describe them when made, can appreciate the perseverance and the labour which have gone to the making of Dr. Allen's book and subsequent writings. I am sure we rejoice with him that he has been the means of enabling a clear step forward to be made in the treatment of a distressing complaint.

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A SIMPLE SYSTEM OF SKELETON SPLINTING.

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THE value of skeleton splinting in the treatment of gunshot fractures has been generally recognized during the present war. Lieutenant-Colonel Robert Jones¹ was responsible for the introduction of this type of splint, and for the extension of its use in our army medical service. I have previously described² how the aluminium stapled strips contained in the field fracture box may be used to make splints of this kind. These stapled strips, however, having been designed to form imitations of the classical solid splints, do not afford an ideal method of coupling lengths for the formation of skeleton frames. The joints effected by the method are not mechanically sound, and hinge formation is not possible. I propose here to describe a system of coupling which has not these defects, and, moreover, one in which the process can be easily and rapidly carried out.

MATERIAL AVAILABLE.

Aluminium strips, $\frac{1}{2}$ in. by $\frac{3}{8}$ in., form splints which are easily malleable by hand, and are sufficiently stable for field purposes. In the case of the larger splints for the lower extremity, however, the material is not always sufficiently rigid for prolonged treatment. Further, at the present time the supply of aluminium for surgical purposes is limited.

There are similar objections to the use of copper and zinc alloys; annealed mild steel appears to be the most satisfactory material available. Annealed steel, $\frac{1}{2}$ in. by $\frac{3}{8}$ in., has much greater vertical rigidity than aluminium, and though it has more lateral spring, it is sufficiently malleable for practical use.

I will therefore describe the system of coupling in relation to the use of annealed mild steel.

Specification of Material.

The stock material consists of five-foot lengths of annealed mild steel $\frac{1}{2}$ in. by $\frac{3}{8}$ in. This material is of standard type, and is sold by any iron merchant. The strips are drilled throughout their length at 1 in. intervals with holes of $\frac{3}{8}$ in. diameter. The holes must be accurately distanced throughout the strips.

Split steel rivets $\frac{3}{8}$ in. by $\frac{3}{8}$ in. are required to couple the

various lengths after they have been bent to form the splint required.

Tools Required.

A *cramp* of the new pattern supplied in the field fracture box; this serves to hold the strips while they are being bent in the direction of their vertical section.

A *screw wrench* with slots $\frac{1}{8}$ in. by $\frac{3}{8}$ in. cut in the jaws $\frac{1}{8}$ in. from the shaft (Fig. 1). This wrench holds the strips and supplies the leverage for bending them; it also serves as a hammer.

A *hacksaw* for cutting the material.

A *triangular file* for trimming the ends or for cutting the strips if the saw be not available.

A pair of "bell" *pliers* with a screwdriver end on one handle; the latter is used to spread the rivets, and the pliers to crush them after they are in place (Fig. 2).

FIG. 1.—Screw wrench with $\frac{1}{8}$ in. by $\frac{3}{8}$ in. slots cut in jaws, holding a strip of splinting.

Method of Cutting Strips.

To divide the mild steel strips at the required level the material is cut half through with a hacksaw, and then snapped off by hand. In using the hacksaw, the tool should only bear by its own weight lest the blade be broken.

The triangular file can be used for the same purpose, but is not as neat or quick to work with.

Method of Bending Strips.

The strips can be moulded on the flat by hand; if a sharp angular bend is required, the screw wrench should be used.

To bend the material on edge, the strip is fitted into the cramp, the screw wrench is fitted home on the strip close to the cramp, and then used to lever the material to the desired angle (Fig. 1). A right angle is the sharpest bend which can be effected in this way, unless the material is previously heated, and even then there is a tendency for the strip to buckle; this tendency is overcome by removing the strip from the cramp in the course of the process and beating out the angle on an anvil. If the part of the strip to be bent is first heated in the flame of a Primus stove, the procedure is much facilitated.

Method of Coupling Strips.

Strips are united in their long axis by passing split rivets through opposed holes. The rivets are then spread with the screwdriver end of the pliers and finally crushed or hammered out (Fig. 2). Three rivets give a firm longitudinal junction.

FIG. 2.—Side view of two lengths of splinting, showing (1) rivet in place, (2) spread, (3) crushed down.

A hinge joint is formed by a single rivet.

A rigid joint at any angle is made by strutting such a hinge joint (see Fig. 3, D).

Completion of Splint for Application (Pads and Slings).

The only part of these splints which requires formal padding is the crutch in those of the modified Thomas's pattern (shown in Fig. 3 at A, in Figs. 6 and 11, and in Fig. 12 at C). This is best effected by winding tow evenly on to the part of the frame which forms the crutch; the tow is then fixed by bandaging firmly over it. For treating compound fractures in the early stage, it is desirable to cover the pad so formed with impermeable material. I have found a length of bicycle inner tube the most satisfactory; this should be rolled on to the splint in the same way as a rubber cricket bat handle is put on; it is then fixed at either extremity with a strip of adhesive plaster.

In splints for the upper extremity the crutch may often be sufficiently padded by passing a length of stout drainage tube on to that part of the frame.

In general, the splints are completed with slings. These are best made from some adaptable but inextensible material, such as old linen. In certain cases troughs of