

Clinical Usefulness of the Wilkerson-Heftmann Blood Sugar Test

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The need of a simple blood sugar test of practical clinical value has long been apparent. Since the number of diabetics in this country, recognized and unknown, approaches two million, it is evident that the great majority must of necessity receive their diagnostic and therapeutic services from general practitioners, often remote from laboratory facilities. The frequency of a high renal threshold for sugar among diabetics makes inadequate the sole use of urinary tests upon which many practitioners depend. On the other hand, a low threshold is not uncommon, among both diabetics or nondiabetics; patients with renal glycosuria are not infrequently being treated as diabetics for want of blood sugar determinations. The blood sugar tests in general use are technically complicated, time-consuming and too expensive for frequent use as a routine measure.

In 1948 Wilkerson and Heftmann¹ reported a capillary blood sugar test designed for screening purposes in diabetic surveys. This technic is extremely simple and rapid, requiring a minimum of equipment for its performance, and utilizing tablets both as reagents and for heating. This principle of the method consists in the reduction of ferricyanide, the unreduced portion of which oxidizes an iodide to form iodine, which in turn reacts with soluble starch to give a blue coloration to the solution. By incorporating a definite quantity of ferricyanide in the reagent tablet, the test indicates the glucose content of the blood as either above or below a specified level; a clear solution (showing complete reduction of the ferricyanide) indicates a glucose value above, and a blue solution (incomplete reduction of the ferricyanide) a value below, the predetermined level.

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The protein in the blood solution, precipitated by other reagent tablets, is forced to the top of the test tube by the steam of the heating process, forming a cake which is easily scooped off. This eliminates a time-consuming filtration procedure. The test, moreover, shows *true glucose*, since all non-glucose reducing substances are eliminated in the process of protein precipitation. The equipment, together with a supply of tablets sufficient for 50 tests, is packed for convenient transport in a container the size of an ordinary cigar box. The test is rapid, requiring about five minutes for its performance, and so simple that a trained technician is not needed.

When the test became available for general use in 1949, provision was made for use of three blood sugar test levels: 180, 130, and 50 mg. per 100 cc. Each of these levels is of high clinical significance, namely, (1)—below 130 mg. per cent, the range of normal and hypoglycemic values, the latter supplemented by the 50 mg. per cent technic; (2)—between 130 and 180 mg. per cent, the range of satisfactory diabetic control; and (3)—above 180 mg. per cent, the range of unsatisfactory or poor diabetic control.

CLINICAL STUDY

With these facts in mind, the value of the Wilkerson-Heftmann test was explored under clinical conditions². Cases from the private practice of the senior author were first utilized, being selected only on the basis of the need of a blood sugar determination as an aid in clinical evaluation. Later a number of cases from the Outpatient Diabetic Clinic of the University of Nebraska, and fifteen juvenile diabetics in residence at the Springdale Camp were included. In the total study, more than 400 tests were made in caring for 110 ambulatory patients of all ages and with diabetes of

all degrees of severity, and in twelve nondiabetic cases presenting diagnostic problems or used as normal controls.

Tests were made both for diagnostic and therapeutic purposes. In most cases arterial (capillary) blood was used; a number of venous blood specimens were also tested in special cases. A blue color was read as minus (below the designated level); a distinctly clear, colorless result was read as plus (above the level); and a light or indefinite blue coloration was read as plus-minus (assuming the blood sugar to be slightly above or slightly below the level).

DEPENDABILITY OF THE TEST

Wilkerson and Heftmann¹ admitted a possible error of 10 mg. per 100 cc. in their test. The result of fifty tests at the 180 level were obtained with determinations by a true glucose method (Somogyi-Nelson). There was perfect agreement in 46; in 21, in which the report was 170 or below, the color was blue; in 25 at 180 or above, the result was colorless; in four tests on the borderline (between 170 and 180) the result was either dark blue, light blue, or clear.

Haunz and Keranen³ found a "high degree of accuracy" in this test; they report only seven discrepancies among 200 capillary tests when comparisons were made with the determination of true glucose by using venous blood.

In sixteen cases we found complete agreement in all but four. In one case, where the Folin-Wu test was 107, the Wilkerson-Heftmann test indicated the blood sugar over 130 and under 180. In another case the blood sugar was 145 by the Folin-Wu test, and the Wilkerson-Heftmann test indicated plus-minus 130. A third case with the Folin-Wu blood sugar 195, the report by the Wilkerson-Heftmann method was over 130 and under 180. In a fourth case, in which Folin-Wu blood sugar was 114, the Wilkerson-Heftmann test indicated the blood sugar over 130 and under 180.

In interpretation of these results, one must keep in mind the fact that the Wilkerson-Heftmann test indicates true blood glucose value, whereas the Folin-Wu method includes nonglucose reducing substances, and thus the blood sugar report may be falsely high. Mosenthal and Barry⁴ reported nonglucose reducing substances as high as 78; they found high and unpredictable variations. Haunz and Keranen³ in a study of 100 cases in which they compared the Folin-Wu and Somogyi-Nelson methods found non-sugar reducing substances ranging in amounts from 2 to 72 mg. per 100 cc. Both groups of authors found sugar reducing substances in excess of

30, in 38 per cent of their cases. It has been assumed that the non-sugar reducing substances could be arbitrarily taken to be 30, but the variations are now known to be much greater.

It can thus be seen that the lack of complete agreement of the Wilkerson-Heftmann and Folin-Wu tests does not necessarily indicate actual discrepancies in the last three cases cited above. In the first case, however, in which the value obtained by the Wilkerson-Heftmann method is greater than that obtained by the Folin-Wu method, this explanation cannot apply. The result may be considered an inaccuracy. Thus a single unexplained inaccuracy was found in a total of 32 tests by the Wilkerson-Heftmann method.

THE TEST AS AN AID IN DIAGNOSIS

There is general agreement that a fasting blood sugar in excess of 130 mg. per 100 cc. is presumptive evidence of diabetes. The converse is not necessarily true; a mild diabetic may have a normal fasting blood sugar. However, by checking the blood sugar two hours after an ample carbohydrate meal, the number of erroneous results can be minimized. At this time interval, a level below 130 is almost positive proof of the nonexistence of diabetes, whereas a reading above that level would at least place the diagnosis in a borderline status. Hence, if only a single blood sugar test is to be made, the best time is two hours after a meal. For more conclusive evidence, glucose tolerance curves may have to be employed. The Wilkerson-Heftmann test can be used for this purpose. Glycosuria with the blood sugar never above 130 must be renal glycosuria; elevation of the blood sugar over 180 persisting for two and three hours after taking glucose must indicate diabetes.

THE TEST AS AN AID IN THE TREATMENT OF DIABETES

Successful treatment of the diabetic patient depends upon clinical judgment supported by adequate laboratory aids. With ideal control, the patient should not only maintain weight and strength, but should also keep free from glycosuria and hyperglycemia. Tests of the urine may be sufficient guide in ordinary routine management with occasional blood sugar tests. However, when the renal threshold is abnormal, the routine use of blood sugar tests may become essential. In our Outpatient Clinic we regard a blood sugar of 150 by the Folin-Wu method as the ideal fasting level for patients requiring insulin. We believe that the blood sugar range of 130 to 180, two to three hours after meals, is additional evidence of satisfactory control. Blood sugar tests below

130 or above 180, in our opinion, required adjustments in diet or insulin or both. The Wilkerson-Heftmann test thus helps us to identify the desired range of blood sugar.

The past quarter century has witnessed a decided trend towards simplification in every phase of diabetic management, diet, insulin administration, and the tests for glycosuria and acetonuria. All of these simplified procedures have tended to permit a more normal life for the diabetic, and also the promotion of better control of the disorder.

A simple blood sugar test is in line with this trend and can fill an urgent need of many general practitioners and internists. Such a test, to have maximal value, should be technically uninvolved, requiring a minimum of equipment; it should not be time-consuming and so inexpensive that frequent use can be encouraged. The Wilkerson-Heftmann test meets all these criteria. The fact that it gives true glucose estimations enhances its value. The test set, including all necessary equipment and reagents, is sufficiently compact for easy transport and is thus made available for use in the home of the patient as well as in the physician's office. With this method either venous or capillary blood can be used in accordance with indications and needs. As shown by our study, it is useful both diagnostically and therapeutically in the management of diabetes.

That the test has its limitations is quite obvious. Of the fifteen children in the Springdale Camp during the 1951 season given tests several times throughout the day, only one showed sufficient stability of the blood sugar to permit evaluation. Such diabetics show fluctuation in the blood sugar to a notorious extent. This test does not indicate the full degree of fluctuation, since it merely indicates a level above 180.

The same situation may be found in diabetic emergencies. In diabetic coma, for instance, the test would have no value in guiding the therapy during the stages of highly elevated blood sugar although, as has been suggested by Haunz and Keranen³, it could be useful in differentiating between coma due to acidosis, hypoglycemic shock, or cerebrovascular disorders. Similarly, in febrile and post-surgical states, with fluctuations and unpredictability of the blood sugar, its usefulness would also be limited. Such eventualities, however, are mainly managed in hospitals where the laboratory facilities are likely to be available for more exact blood sugar tests. Exceptions may conceivably occur in thinly populated areas, with the patient too ill for transportation to a remote hospital, in which case the physician may be

forced to provide emergency treatment in the home.

The main limitation inherent in the test is the absence of blood sugar level definition within the areas of the blood sugar ranges. This does not necessarily constitute a serious impediment to its usefulness. In the normal and hypoglycemic range this limitation is not grave, although an additional level of 100, the upper limit of true glucose normals, might be desirable. Neither can there be serious objection to this lack of definition within the range of good diabetic control; we cannot concede important significance to the specification of particular levels between those of 130 and 180 mg. per cent. In the range above 180 mg. per cent, however, the deficiency may assume significant proportions, as indicated in the discussion of the management of diabetic emergencies. This defect can be corrected to a large extent by providing two higher levels, at about 250 mg. per cent and at 350 mg. per cent. Such can be accomplished either by developing additional reagent tablets or by a modification of the technic.

SUMMARY

The Wilkerson-Heftmann blood sugar test is rapid, simple, inexpensive and accurate. While it does not give the exact determination of the blood sugar it nevertheless enables one to know that it is in one of the four clinically significant blood sugar ranges—over 180; between 130 and 180; between 130 and 50; and under 50.

In 110 cases of diabetes and twelve cases of nondiabetic conditions or normal controls the test has been utilized to explore its value in clinical use. It can be concluded that the test is eminently useful in both diagnosis and guidance of therapy.

There are limitations inherent in the method, its chief deficiencies becoming obvious in the handling of diabetic emergencies. Two higher blood sugar testing levels are suggested to correct this fault.

In spite of its limitations, the test has been useful in a majority of diabetic problems and we do not hesitate to recommend it for general acceptance and wider use.

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