Self testing for diabetes mellitus

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Abstract

Objective—To develop a simple, economically viable, and effective means of population screening for diabetes mellitus.

Design—A postal request system for self testing for glycosuria with foil wrapped dipsticks. Preprandial and postprandial tests were compared with a single postprandial test. The subjects were instructed how to test, and a result card was supplied on which to record and return the result. All those recording a positive test result and 50 people recording a negative result were invited for an oral glucose tolerance test.

Setting—General practice in east Suffolk, list size 11 534.

Patients—All subjects aged 45-70 years registered with the practice were identified by Suffolk Family Health Services Authority (n=3057). The 73 subjects known to have diabetes from the practice's register were excluded, leaving 2984 subjects, 2363 (79.2%) of whom responded. 1167 subjects completed the single test and 1196 the two tests.

Main outcome measures—Response rate and number of patients with glycosuria. Sensitivity, specificity, and positive predictive value of a single postprandial test and preprandial and postprandial tests. Number of new cases of diabetes identified and cost of screening.

Results—Of the patients completing the single postprandial test, 29 had a positive result; an oral glucose tolerance test showed that eight (28%) had diabetes, six (21%) impaired glucose tolerance, and 14 (48%) normal glucose tolerance. 44 of the group who tested before and after eating had a positive result; nine (20%) had diabetes, five (11%) impaired tolerance, and 26 (11%) normal tolerance. Screening cost 59p per subject and £81 per case detected. Of the 17 people with previously undiagnosed diabetes, eight were asymptomatic and 11 had not visited their general practitioner in the past three months.

Conclusions—A postal request system for self testing for postprandial glycosuria in people aged 45-70 is a simple and effective method of population screening for diabetes mellitus.

Introduction

Many subjects with diabetes mellitus in the community are thought to remain undiagnosed. The figures are uncertain, but it is often quoted that there are as many cases undiagnosed as diagnosed. Almost half of subjects will tolerate symptoms, even those specific to diabetes, for four months before diabetes is diagnosed, a fifth tolerate symptoms for more than one year, and up to a fifth of subjects present with established complications.¹

The prevalence of diabetes in the United Kingdom is about 1%.² Non-insulin dependent diabetes mellitus accounts for about 80% of cases in people aged over 40 years; the prevalence increases with age and is highest

in men in the older age groups.³ Patients with the condition may remain symptom free for years, but studies have suggested that if diabetes is left uncontrolled there is a higher risk of macrovascular complications, including coronary, cerebral, and peripheral vascular atherosclerosis as well as microangiopathic complications.⁴ For example, higher blood glucose concentrations are associated with a greater risk of developing retinopathy in subjects with non-insulin dependent diabetes.⁵

Roughly 4-5% of NHS money is spent on caring for those with diabetes, a substantial amount of which is spent on treating complications.⁶ Early intervention and optimal treatment of non-insulin dependent diabetes may reduce or prevent progression of some of the complications; dietary reduction of hyperglycaemia has been shown to produce a sustained reduction of pre-existing proteinuria.⁷ Detection of those at risk of foot and eye problems enables regular screening and, if necessary, specific treatment to be started. Early detection and follow up has obvious benefits in foot care as subjects with non-insulin dependent diabetes have a greatly increased incidence of both foot ulceration and amputation, and introducing foot clinics to deal with such problems has halved amputation rates.^{8,9} Early detection of non-insulin dependent diabetes seems to have important potential medical, economic, and social advantages that support the need for community screening.

We conducted a study to develop a simple, economically viable, and effective method of screening for diabetes. We tested the feasibility of and compliance with a postal request system for self testing for glycosuria. We compared the effectiveness of testing once postprandially with testing both fasting and postprandially in detecting non-insulin dependent diabetes.

Subjects and methods

We studied the patients from one practice in Suffolk with a list size of 11 534. All subjects aged 45-70 years (n=3057) were identified by the Suffolk Family Health Services Authority, which supplied address labels and a list of names and addresses of patients registered with the practice. Patients known to have diabetes were excluded by checking against the practice's register (n=73 in this age group). A carefully designed letter and instruction card (which has been successfully piloted on 25 patients attending a medical outpatient department) was posted to the remaining 2984 subjects. Subjects were divided into groups by age; the five groups were 45-49 years, 50-54, 55-59, 60-64, and 65-70. The total population was randomly split by random numbers into two groups; in group 1 patients were asked to test for glycosuria using the enclosed foil wrapped dipstick once, one hour after the main meal (group 1) and in group 2 patients were asked to test before breakfast and one hour after breakfast. There were 1492 subjects in each group. The subjects were

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TABLE I—Response rate and detection of glycosuria in subjects asked to self test for diabetes mellitus

Age group (years)	No of subjects	No (%) who returned cards	No (%) recording glycosuria	95% Confidence interval for response rate (%)
45-49	683	488 (71)	12 (2.4)	67.5 to 74.5
Men	338	227 (67)	9 (4)	61.9 to 72.1
Women	345	261 (76)	3 (1.1)	71.4 to 80.6
50-54	627	484 (77)	15 (3)	73.6 to 80.4
Men	305	222 (73)	11 (5)	68 to 78
Women	322	262 (81)	4 (1.5)	76.6 to 85.4
55-59	558	458 (82)	12 (2.6)	78.8 to 85.2
Men	252	207 (82)	9 (4.3)	77.2 to 86.8
Women	306	251 (82)	3 (1.2)	77.6 to 86.4
60-64	538	453 (84)	16 (3.5)	80.8 to 87.2
Men	268	216 (80)	9 (4.2)	75.1 to 84.9
Women	270	237 (88)	7 (3)	84.1 to 91.9
65-70	549	480 (86)	18 (3.7)	83 to 89
Men	234	269 (88)	12 (5.7)	83.8 to 92.2
Women	315	211 (85)	6 (2.2)	81 to 89

TABLE II—Prevalence of diabetes before and after screening in a Suffolk practice

Age (years)	No (%) of men with diabetes			No (%) of women with diabetes		
	Before screening†	Detected by screening†	Total‡	Before screening*	Detected by screening†	Total‡
45-49	4/432 (1.2)	1/227 (0.5)	5/231 (2.2)	3/349 (0.9)	1/261 (0.4)	4/264 (1.5)
50-54	9/314 (2.9)	4/222 (1.8)	13/231 (5.7)	4/332 (1.2)	2/262 (0.8)	6/266 (2.3)
55-59	9/266 (3.4)	1/207 (0.5)	10/216 (4.6)	6/316 (1.9)	1/251 (0.4)	7/257 (2.7)
60-64	11/283 (3.9)	2/216 (0.9)	13/227 (5.8)	6/276 (2.2)	0/237	6/243 (2.5)
65-70	13/256 (5.1)	4/211 (1.9)	17/224 (7.6)	8/333 (2.5)	1/269 (0.4)	9/277 (3.3)
All ages	46/1461 (3.1)	12/1083 (1.1)	58/1129 (5.2)	27/1596 (1.7)	5/1280 (0.4)	32/1307 (2.5)

*Includes all patients registered before screening.

†Includes only patients who returned cards; those with known diabetes excluded.

‡Includes patients who returned cards and those with known diabetes.

asked to record the result(s) and return the addressed result cards; the postage was prepaid.

All subjects recording glycosuria were contacted within a week after returning the cards and invited to the hospital for an oral glucose tolerance test. Subjects were given 75 g of glucose and blood glucose concentrations were measured at baseline and at 30 and 120 minutes by the glucose oxidase method. Subjects were classified as normal, diabetic, or having impaired glucose tolerance according to World Health Organisation criteria.¹⁰ To determine the false negative rate a randomly selected group of 50 subjects recording negative test results were also invited for a glucose tolerance test. All subjects having a test were given the results on the day of the test. If subjects were found to have diabetes they were asked to contact their general practitioner, who was informed of the test result, and were given simple dietary advice. Those with impaired glucose tolerance were told that they did not have diabetes and to make no dietary changes but were informed that they would be invited to be retested in six months.

The cost of screening was calculated per case diagnosed and per person screened. Costs included stationary (envelopes, paper, and result cards), postage (second class return postage with a business reply licence), labour costs (clerical time for 10 hours), address labels and computer list (supplied by the family health services authority), and dipsticks. The cost of performing an oral glucose tolerance test (equipment and reagents) was calculated. In each age group the number of cards returned was recorded and after those who had moved or died were excluded a return rate was calculated. The difference in return rates across the age groups was calculated by the χ^2 test for linear trends. The return rate of cards among subjects in group 1 and group 2 was compared by the χ^2 test. The sensitivity of each method of testing (ability of test to detect glycosuria, when the person tested had either impaired glucose tolerance or non-insulin dependent diabetes on oral glucose testing) was calculated by dividing the number of true positive results by the sum of true positive and false negative results and multiplying by 100. The 50 subjects with negative dipstick results who were invited for a

glucose tolerance test were said to have false negative results if the glucose tolerance test found impaired glucose tolerance or diabetes and true negative results if the tolerance test gave a normal result. The specificity (the ability of the test to give a negative result when the person tested is free of the disease) was calculated by dividing the number of true negative results by the sum of true negative and false positive results and multiplying by 100. The sensitivity, specificity, and positive predictive value of the method of testing in groups 1 and 2 was compared with the χ^2 test.

Results

Of the 2984 cards sent out, 17 were returned because the subject had moved out of the area. Eight subjects died either shortly before or during the screening procedure; only four subjects reported difficulty carrying out the test. A total of 2363 (79.2%) cards were returned. Table I shows the return rate according to age and sex. The return rate increased significantly across the groups from 71.4% in those aged 45-49 years to 86.5% in those aged 65-70 ($\chi^2=11.61$, $df=4$; $p<0.05$). Seventy three subjects recorded glycosuria (table I). Of those with glycosuria, 68 (93%) attended for an oral glucose tolerance test.

The test card was returned by 1167 (78%) subjects in group 1 and 1196 (80%) in group 2 ($\chi^2=1.71$, $p=0.19$). Among the 29 subjects with glycosuria in group 1, the oral glucose tolerance test found that eight (28%) had diabetes, six (21%) had impaired glucose tolerance, and 14 (48%) had normal glucose tolerance. Of the 44 patients with glycosuria in group 2, nine (20%) had diabetes, five (11%) had impaired glucose tolerance, and 26 (59%) had normal glucose tolerance. Two of the nine subjects with diabetes in group 2 had only postprandial glycosuria and would have been missed if they had tested only a fasting sample; no subject had fasting but not postprandial glycosuria.

The sensitivity of the test was 93% (95% confidence interval 83.4% to 102.6%) in group 1 and 87% (76.2% to 98.6%) in group 2 ($\chi^2=0.02$, $p=0.89$). As no cases of diabetes were identified in the 50 subjects without glycosuria, if only diabetes is considered a true positive then the sensitivity of both methods of testing is 100%. The positive predictive values of the tests were 50% (31.2% to 68.8%) in group 1 and 35% (20% to 50%) in group 2 ($\chi^2=0.63$, $p=0.43$). Excluding those with impaired glucose tolerance gave positive predictive values of 28.6% (11.6% to 45.6%) and 22.5% (13.9% to 31.1%) respectively ($\chi^2=0.19$, $p=0.66$). In all, 17 subjects with diabetes and 11 with impaired glucose tolerance were identified. Of those with diabetes, 11 had a fasting glucose concentration diagnostic of diabetes. Oral glucose tolerance testing in the 50 randomly selected subjects with negative dipstick results found no cases of diabetes but three cases of impaired glucose tolerance. The specificity of the test was 63% (44.8% to 81.2%) in group 1 and 48% (32.2% to 63.8%) in group 2 ($\chi^2=0.67$, $p=0.41$). If only diabetes is considered a true positive result and not impaired glucose tolerance the specificities of the two methods were 55.5% (36.7% to 73.7%) and 44% (28.3% to 59.7%) respectively.

Table II shows the distribution of known cases, those identified at screening, and the prevalence of diabetes after screening. Before screening the prevalence of diabetes in people aged 45-70 years was 2.4%, as a result of screening this had risen to 3.8%. The percentage of cases identified in men was roughly double that in women. Eight subjects with previously undiagnosed diabetes were asymptomatic when directly questioned, and 11 had not attended their general practitioner in the preceding three months. Total cost of screening was £1386 and costs were broken down as

follows: stationary £36, postage £810, cards and testing strips £300, address list and labels £100, clerical costs £30, and cost of glucose tolerance tests £110. The cost for each person screened was 59p and for each case of diabetes diagnosed was £81.

Discussion

The question of both who and how to screen for glucose intolerance is both topical and controversial. The new general practitioners' contract requires testing for glycosuria in all those aged over 5 years when they register and at three yearly health checks. Attendance rates for such checks are poor and the exercise is costly in time and resources and largely unproductive.

Urine testing for glycosuria was used extensively in the United Kingdom in the 1960s when large screening projects were performed.^{11,12} The Birmingham study screened over 19 000 subjects combining personal contact by the general practitioner with postal request and reminder letters. The group screened 95% of the population, although the response to postal request was poor (36%) and found as many cases previously undiagnosed (0.69%) as known cases (0.64%).¹¹ The Bedford study achieved a high return rate (67%) using labour intensive methods. Both these studies were performed before the introduction of the 1985 WHO criteria for diagnosing diabetes and reported a high false negative rate for urine analysis (Birmingham 9.7%, Bedford 13.9%). From them, it was concluded, perhaps erroneously, that screening for diabetes using glycosuria had pitfalls which discouraged further population based studies.¹³ However, if the 1985 WHO criteria had been applied (previously a whole blood glucose concentration of 6.7 mmol/l two hours after a 50 g load was diagnostic of diabetes; this was raised to 10 mmol/l after a 75 g load), the rate of false negative results would have dropped to around 2%.

Furthermore, many problems might have been avoided if the oldest and youngest subjects had not been screened because groups with a low and high renal threshold would have been excluded. Exclusion of these patients and clearly defined diagnostic criteria for diabetes might have improved the sensitivity and specificity of glycosuria as a screening test.

In terms of cost and acceptability to the subject screening for glycosuria is potentially one of the better options. Many studies have evaluated other means of screening, including blood glucose concentrations two hours after glucose load, random blood glucose concentrations, and glycated haemoglobin concentrations. None of these tests has been widely recommended, and the best standard is the oral glucose tolerance test, but it is not practical to use for large population studies.

Apart from poorly documented *Woman* magazine study¹⁴ this is the first large study in this country to use urine dipstick testing since the introduction of the 1985 WHO criteria. Other studies since 1985 which have evaluated glycosuria had suggested that it would be unsuitable as a method of screening. In the Islington study it was shown that fasting glycosuria had a poor sensitivity (32%), but this improved when glycosuria was measured after a glucose load (72%), although there was some loss of specificity.¹⁵ However, this observation was made in a small number of subjects during an oral glucose tolerance test. Bitzen and Schersten showed that testing for glycosuria was not as effective as blood glucose testing, but they screened all ages and used random urine testing.¹⁶

Our return rate was remarkable for such a simple approach and compares favourably with more labour intensive techniques. The population was registered with a typical Ipswich practice and had not been previously screened; we have since screened one rural

and one urban practice and have obtained similarly high return rates (79.3% and 73% respectively). The increased awareness of the general public of health prevention, and the simple, clear method of testing and personal approach from the general practitioner may be responsible for the high return rate.

The percentage of those identified with glycosuria was similar to that in other large earlier studies. There was no advantage in multiple tests (fasting and postprandial) over a single postprandial test. More cases of diabetes were identified in men than women across all ages, and it may be that women have diabetes detected at their more frequent hospital attendances. The positive predictive value of the test is acceptable for a screening method and in most patients a fasting glucose concentration rather than a formal oral glucose tolerance test would be sufficient. Costs of the procedure could be reduced by posting in one envelope to those at the same address (about 40-50% of those screened), and some practices could generate their own computer lists and address labels.

The fact that a substantial number of patients were asymptomatic and that most of those with diabetes had not attended their general practitioner in the preceding three months emphasises the need for a direct approach to the patient. The prevalence of diabetes in the practice screened was already higher (2.1% in the 45-64 years age group) than would be expected from other United Kingdom figures (1.28% in those aged 45-64 in Poole), which makes the increase in prevalence of 0.6% even more encouraging. Twenty two months after screening only one further case of diabetes in the screened population had been diagnosed; recent incidence figures for non-insulin dependent diabetes suggest nine cases would have been expected (British Diabetes Association conference, April 1991).

Further evaluation of the rate of false negative results is needed, but we propose that screening for diabetes by self testing for postprandial glycosuria in a restricted age group is successful, acceptable to patients, and economically viable. We are currently extending the study to evaluate the optimal interval for screening and to see if the success of this method is reproducible across different areas.

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