International Journal of Diabetes Mellitus 2 (2010) 43–46

Contents lists available at ScienceDirect

International Journal of Diabetes Mellitus

journal homepage: ees.elsevier.com/locate/ijdm

Review

The challenge of undiagnosed pre-diabetes, diabetes and associated cardiovascular disease

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ARTICLE INFO

Article history:
Received 7 August 2009
Accepted 24 October 2009

Keywords:
Diabetes
Pre-diabetes
Undiagnosed diabetes
HbA1c
Cardiovascular disease

ABSTRACT

Objective: To present the challenges of undiagnosed pre-diabetes, diabetes and associated cardiovascular disease.
Results: A substantial number of people with diabetes and pre-diabetes remain undiagnosed worldwide. Without preventive measures, pre-diabetes progresses to overt diabetes at the rate of approximately 5% per year. Both diabetes and pre-diabetes are associated with vascular complications.
Conclusion: Undiagnosed pre-diabetes and diabetes is a major health problem, and we recommend widespread screening for diabetes. An international expert committee has recommended that HbA1c be used for the diagnosis of diabetes. Further studies are needed before HbA1c can be used as a diagnostic test for gestational diabetes.

1. Introduction

The prevalence of diabetes and pre-diabetes has reached epidemic proportions. It is estimated that currently, approximately 7.8% of the US population or 23.6 million Americans have diabetes [1]. Of these, 17.9 million people are diagnosed and 5.7 million people have diabetes that has not been diagnosed. In addition, there are an estimated 57 million people who have "pre-diabetes" [1]. In 2005–2006, the crude prevalence of total diabetes in the US among people aged ⩾20 years was 12.9%, of which approximately 40% (of cases) were undiagnosed. In addition 29.5% had pre-diabetes [2]. In the UK, the overall weighted prevalence of diabetes was 9.1% and 1.7% had undiagnosed diabetes. Of the cases of diabetes, 18.5% were undiagnosed [3]. It is projected that the global prevalence of diabetes will approximately double by the year 2030 [4]. Worldwide, the number of people with pre-diabetes (impaired glucose tolerance) in the age group 20–79 was 308 million in 2007, and is expected to increase to 418 million by the year 2025 [5].

Pre-diabetes, as diagnosed by impaired fasting glucose (IFG) or impaired glucose tolerance (IGT), progresses to overt diabetes at the rate of approximately 5% per year [6] unless some interventions are introduced [7]. Diabetes is associated with an increased risk of microvascular (diabetic retinopathy, nephropathy, and neuropathy) [8], as well as macrovascular complications such as myocardial infarction, stroke or peripheral vascular disease [9]. The majority of patients with type 2 diabetes mellitus die due to cardiovascular complications [10]. Thus, a missed diagnosis of diabetes amounts to a missed diagnosis of cardiovascular disease [11].

2. Diagnosis of diabetes and pre-diabetes

Since both fasting and postprandial glucose levels in the population are distributed in a unimodal fashion, the diagnosis of diabetes and more recently pre-diabetes has been made by somewhat arbitrary criteria. Prior to the criteria for diagnosis of diabetes promulgated by the National Diabetes Data Group [12], there was no agreement about the levels of plasma glucose at which a diagnosis of diabetes mellitus could be made. These criteria were revised in 1997 [13], and are still used widely to make a diagnosis of diabetes mellitus. At that time, the glycemic threshold for making a diagnosis of diabetes was lowered from a fasting plasma glucose of 140 mg/dl to a plasma glucose level of 126 mg/dl. Also at that time, pre-diabetes was defined as either an impaired fasting glucose (IFG), i.e., FPG 110–125 mg/dl, or impaired glucose tolerance ([IGT), i.e., 2 h post glucose load plasma glucose 140–199 mg/dl. The criteria for impaired IFG were subsequently revised to FPG 100–125 mg/dl [14]. The reasons for this decision by the expert committee were several, and are discussed in detail in their report [14].

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1877-5934
doi:10.1016/j.ijdm.2009.10.004

2.1. Progression and prevention of pre-diabetes to diabetes

It is well known that people with pre-diabetes have an increased risk of progression to type 2 diabetes mellitus [6,15]. Several studies have followed the progression of IFG and IGT to the development of overt diabetes. An evaluation of these studies reveals that although there are some differences among studies, it appears that IFG or IGT progresses to overt diabetes at the rate of approximately 5% per year. The risk appears to be similar with isolated IFG or IGT, and is highest for those who have combined IFG and IGT [6].

A review of several studies of prevention of diabetes from pre-diabetes revealed that with life style interventions the relative risk reduction ranged from 28% to 67% while with the use of some drugs the relative risk reduction was 26–60% [16]. A larger meta-analysis to quantify the effectiveness of pharmacologic and life-style interventions to prevent or delay type 2 diabetes in people with IGT determined that the pooled hazard ratios were 0.51 (95% confidence interval 0.44–0.60) for life style interventions vs. standard advice, 0.70 (0.62–0.79) for oral diabetes drugs vs. controls, 0.44 (0.28–0.69) for Orlistat vs. controls and 0.32 (0.03–3.07) for herbal remedy Jiangtang recipe vs. standard advice. The authors concluded that life style and pharmacologic interventions reduce the rate of progression to type 2 diabetes in people with IGT, and that the lifestyle interventions seem to be at least as effective as drug treatment [7]. It should be mentioned that at the present time no drugs are approved by the Federal Drug Administration in the USA for the treatment of pre-diabetes.

Although either IFG and/or IGT can be used to make a diagnosis of pre-diabetes, their significance in terms of progression of disease and the cardiovascular complications may not be the same. For example, a study from Mauritius [17] demonstrated that for predicting progression to type 2 diabetes, the sensitivity, specificity, and positive predictive values were 26%, 94% and 29% for IFG and 50%, 84% and 24% for IGT, respectively. The authors concluded that IGT had higher sensitivity over IFG for predicting progression to type 2 diabetes [17].

Similarly in the Fungata study, it was observed that IGT was a risk factor for cardiovascular disease, but IFG was not [18]. An international workshop on impaired glucose tolerance and impaired fasting glycemia [6] concluded that: (i) in the majority of populations studied, IGT is more prevalent than IFG, (ii) IFG is substantially more common amongst men, and IGT slightly more common amongst women, (iii) the prevalence of IFG tends to plateau in middle age, whereas prevalence of IGT rises in old age, (iv) because IGT is more common than IFG in most populations, it is more sensitive (but slightly less specific) for identifying people who will develop diabetes, (v) both IFG and IGT are associated with cardiovascular disease risk factors including hypertension, dyslipidemia and other features of the metabolic syndrome, and finally (vi) in unadjusted analysis, both IFG and IGT are associated with cardiovascular disease and total mortality.

2.2. Vascular complications of pre-diabetes and diabetes

Pre-diabetes has been associated with microvascular [15,19] and macrovascular complications [15,20,21]. Several studies have demonstrated that IGT is associated with an increased risk of cardiovascular mortality [22–24]. Once pre-diabetes progresses to overt diabetes, the risk of cardiovascular disease greatly increases [10,25,26]. It has also been demonstrated that HbA1c levels are continuously and positively associated with cardiovascular and total mortality independent of other risk factors (27–30). In the EPIC study [27], an increase in HbA1c of 1% points was associated with a relative risk of death from any cause of 1.24 (95% CI, 1.14–1.34). Danaei et al. [28] in a global study to assess the relationship of mortality from ischemic heart study and glucose concentration, concluded that higher than optimum blood glucose is a leading cause of cardiovascular mortality in most world regions. Finally, in the studies of Saydah et al. [29], based on the NHANES data, and that of Dale et al. [30], based on a 20 years follow up of newly diagnosed diabetes patients demonstrated that poor long term glycemic control as indicated by increased HbA1c levels is associated with higher cardiovascular and all cause mortality.

In recent years, the controversy, whether the control of hyperglycemia is beneficial to reduce cardiovascular complication risk has been settled. The Diabetes Control and Complications Trial (DCCT) in type 1 [31] and UK prospective diabetes study [32] in type 2 diabetes demonstrated that control of hyperglycemia reduces the risk of microvascular complications of diabetes. In the UKPDS study, there was a 16% reduction in the risk of myocardial infarction, but this difference was not statistically significant. However, there was a correlation between the risk of MI and HbA1c level [33]. In a recent follow up of the UKPDS, it was demonstrated that despite an early loss of glycemic differences, a continued reduction in microvascular risk and emergent risk reductions for myocardial infarction or death from any cause were observed during 10 years of post trial follow up [34]. Based on studies like these [31,34] and the observations that HbA1c levels are continuously and positively associated with cardiovascular disease and total mortality independent of other cardiovascular risk factors [27–30], the American Diabetes Association (ADA) recommended that a HbA1c <7% for microvascular disease prevention, and the general goal of <7% appeared reasonable for many adults for macrovascular risk reduction. In selected individuals, a HbA1c goal lower than <7% might be reasonable if this can be achieved without significant hypoglycemia or other adverse effects of treatment [35]. This leads to the concept that perhaps the lower the HbA1c, the better it was [36]. However, the results of the recent studies, Action to Control Cardiovascular Risk in Diabetes (ACCORD) [37] and Action in Diabetes and Vascular Disease (ADVANCE) study [38] have led to re-examination of the "lower is better" role of hyperglycemia in cardiovascular disease. Neither of these two studies showed any benefit of lowering the HbA1c to 6.4% and 6.3%, respectively; compared with the standard intervention, which achieved a HbA1c level of 7.5% and 7.0%, respectively. Moreover, in the ACCORD study, intensive therapy was associated with increased mortality [37].

Thus, although it is not clear what the 'ideal' target for HbA1c should be, it is apparent from the above discussion that many cases of pre-diabetes and diabetes remain undiagnosed, pre-diabetes increases the risk of progression to overt diabetes, and both pre-diabetes and diabetes are associated with an increased risk of cardiovascular disease morbidity and mortality.

3. Screening for diabetes

Effective treatments are now available to retard the progression of pre-diabetes to diabetes [7,16] and to reduce the cardiovascular risk in diabetes mellitus [31–34,39]. It, therefore, appears reasonable to undertake aggressive screening for pre-diabetes and diabetes to reduce the overall disease burden. However, whether to screen for diabetes or not, and how to screen, remains controversial. The ADA recommends screening for all adults who are overweight and have one of the following additional risk factors: physical inactivity, first degree relative with diabetes, members of high risk ethnic populations, women who have delivered a baby weighing more than 4.1 kg or were diagnosed as having gestational diabetes mellitus, hypertension, HDL – cholesterol level <35 mg/dl or triglyceride level >250 mg/dl, women with polycystic ovarian syndrome, IGT or IFT on previous testing, other clinical conditions

associated with insulin resistance and history of cardiovascular disease [35]. In the absence of above criteria, testing for diabetes and pre-diabetes should begin at age 45 years. If results for diabetes and pre-diabetes are normal, testing should be repeated at least at 3 years intervals with consideration of more frequent testing depending on initial results and risk status [35]. The US Preventive Services Task Force (USPTF) recently updated its guidelines for screening adults for type 2 diabetes mellitus [40]. This report was based on a literature review of existing data in both MEDLINE and Cochrane Library database. Based on their review the USPTF concluded that screening for diabetes in asymptomatic individuals with hypertension (blood pressure $\geqslant$135/80) was indicated. On the other hand, the National Screening Committee (NSC) of UK, after an extensive literature review, concluded that the case for screening for undiagnosed diabetes is probably somewhat stronger than it was at the time of their last review [41]. They also noted that there is a good case for screening for IGT with the aim of preventing some future diabetes and reducing cardiovascular disease. An interesting discussion about whether to screen for diabetes or not has been recently published in the Mayo Clinic Proceedings [42–44].

In the aforementioned discussion, we agreed [44] with the broader screening recommendations of the ADA [35] and Sheehy et al. [42] in supporting more aggressive screening for diabetes, as compared to the USPSTF more restrictive recommendations [40]. Assuming that one is going to undertake screening, the optimal methods for screening are also somewhat controversial. The ADA recommends using FPG and OGTT and presently these are used widely [35]. Both of these tests require measurement of plasma glucose and also require at least an overnight fast. However, the sensitivity of FPG is not very high and fails to detect 30–50% of individuals with diabetes [45,46]. OGTT is inconvenient, costly, time consuming, labor intensive, and has low reproducibility that can add to confusion and uncertainty to confirmation of the diagnosis of diabetes [45,46]. We have suggested in the past that HbA1c may be a reasonable alternative for screening for diabetes [47], possibly including GDM [48]. In recent years, there has been an increasing support for the use of HbA1c for screening purposes [45,46].

Bennett et al. [46], in a systemic review, concluded that HbA1c and FPG are equally effective screening tools for the detection of type 2 diabetes. In a study by McCane et al. [49] it was reported that FPG, OGTT and HbA1c all three significantly predicted the development of retinopathy and nephropathy [49]. A recent consensus statement published by a panel of experts in the area of diagnosis, monitoring and management of diabetes, led by Saudek et al. [50], recommended that: (1) screening standards should be established that prompt further testing and closer follow up including FPG 100 mg/dl or greater, random plasma glucose of 130 mg/dl or greater or HbA1c greater than 6.0%, (2) HbA1c 6.5–6.9% or greater, confirmed by a specific test (FPG or OGTT) should establish the diagnosis of diabetes, (3) HbA1c of 7% or greater confirmed by another HbA1c or a specific test (FPG or OGTT) should establish the diagnosis of diabetes. Although so far, ADA has not endorsed using HbA1c as a diagnostic test, with the consensus of several leading diabetes organizations, ADA's Expert Committee on the Diagnosis and Classification of Diabetes plans to publish guidelines recommending the HbA1c test as a diagnostic tool for type 2 diabetes [51]. The reasons given for this change are that both FPG and OGTT show thresholds for the diabetes specific complications of retinopathy; the variability of glucose measures is actually much larger than that of standardized A1c measurements. While to date there are no criteria for using HbA1c in diagnosing diabetes, A1c has a threshold for retinopathy, can be measured anytime of day without regard to meal status and has less variability [51].

Although it appears that the community of diabetes experts may be close to an agreement about the use of HbA1c for the screening or diagnosis of diabetes, the issue of using HbA1c for similar purposes is more controversial in gestational diabetes mellitus (GDM). Currently, the ADA recommends screening for GDM using risk factor analysis and if appropriate, use of OGTT. A two-step approach, using an initial screening by measuring plasma or serum glucose 1 h after 50 gm oral glucose load and performing diagnostic 100 gm glucose load on a separate day in women who exceed the chosen threshold on 50 gm screening, is recommended [35]. All the disadvantages of using an oral glucose load mentioned above apply even more strongly to pregnant women who already may have reduced tolerance to foods and drinks. Moreover, the glucose load used is even greater [100 gm] compared to the glucose load used in nonpregnant state (75 gm). Anecdotally, the drink has been described as nauseating or even obnoxious by patients, and up to 4% women have reported vomiting following ingestion of oral glucose load [52].

There are, however, few studies supporting the diagnostic utility of HbA1c in GDM. This may be a result of the fact that most of the studies were done in the 1980's [53–57] when HbA1c assays were diverse, and the test was not standardized [47]. Furthermore, these studies were small and the diagnostic criteria used in these studies were not uniform. Thus the conclusions drawn from these studies were not clear.

The results of two recent larger studies from UAE addressing HbA1c in GDM screening and diagnosis are also conflicting regarding the sensitivity and specificity of the test [58,59]. Interestingly both of these studies were performed by the same group. In their earlier study [58], Agarwal et al. observed that HbA1c may have potential as a screening test for GDM but they were not able to confirm that in the subsequent study [59]. In a retrospective study in a Saudi population of 145 women in the third trimester of pregnancy, we observed that the sensitivity of HbA1c in predicting GDM was 87%. The study design did not allow us to calculate specificity [48]. In a recent review by the New Zealand GDM Technical Working Party, this group recommended HbAlc as a practical initial screening test but noted that further research was needed [60]. It is, therefore, apparent that further studies are needed to determine the role of HbA1c in screening and diagnosis of GDM.

4. Conclusion

The prevalence of diabetes continues to increase on a world wide basis. A substantial proportion of subjects with pre-diabetes and diabetes remain undiagnosed. Pre-diabetes progresses to overt diabetes at the rate of approximately 5% unless appropriate interventions are introduced. Both pre-diabetes, and diabetes are associated with an increased risk of cardiovascular complications. Effective modalities to prevent the progression of pre-diabetes to diabetes and to reduce the CV risk of diabetes are now available. Therefore, we believe that aggressive screening of diabetes should be undertaken. However, this issue remains controversial. Although FPG and OGTT are widely used for screening, there is increased recognition of the role of HbA1c for screening purposes. It appears that we will be using HbA1c, not only for monitoring the glycemic control of diabetes, but also for recognition of diabetes in the near future. However, the role of HbA1c in screening for GDM remains uncertain, and further studies are needed to clarify its role for this purpose

Acknowledgement

We would like to thank Jinie Shirey, Division of Endocrinology, Department of Medicine, College of Human Medicine, Michigan

State University, East Lansing for assistance in manuscript preparation.

References

[1] The American Diabetes Association. <http://www.diabetes.org/diabetes-statistics/prevalence.jsp> [accessed 12.08.08].
[2] Cowie CC, Rust KF, Ford ES, Eberthardt MS, Byrd-Holt DD, Li C, et al. Full accounting of diabetes and pre-diabetes in the US population in 1988–1994 and 2005–2006. Diab Care 2009;32(2):287–94.
[3] Pierce MB, Zaniotto P, Steel N, Mindell J. Undiagnosed diabetes – data from English longitudinal study of ageing. Diab Med 2009;26:625–79.
[4] Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diab Care 2004;27(5):1047–53.
[5] IDF – Diabetes Atlas: Prevalence – http://www.eatlas.idf.org/indexcc67.html; 2009.
[6] Unwin N, Shaw J, Zimmet P, Alberti KGMM. Impaired glucose tolerance and impaired fasting glycaemia: the current status on definition and intervention. Diabet Med 2002;19:708–23.
[7] Gillies CL, Abrams KR, Lambert PC, Cooper NJ, Sutton AJ, Hsu RT, et al. Pharmacological and lifestyle interventions to prevent or delay type 2 diabetes in people with impaired glucose tolerance. Systematic review and meta-analysis. BMJ 2007;334(7588):299–307.
[8] Zhiheng H, King GL. Microvascular complications of diabetes. Endocrinol Metab Clin North Am 2004;33:215–38.
[9] Kannel WB, McGee DL. Diabetes and cardiovascular risk factors: the Framingham study. Circulation 1979;59(1):8–13.
[10] Harris MI, Entmacher PS. Mortality from diabetes. In: Harris MI, Hamman R, editors. Diabetes in America. Washington, DC: US Government Printing Office; 1985. p. 1–48 [Publication #85-1468].
[11] Aldasouqi SA, Gossain VV, Little RR. Undiagnosed diabetes equals undiagnosed CVD: a call for more effective diabetes screening. Rev Endocrinol 2009;3:21–3.
[12] National Diabetes Data Group. Classification and diagnosis of diabetes mellitus and other categories of glucose intolerance. Diabetes 1979;28:1039–57.
[13] The expert committee on the diagnosis and classification of diabetes mellitus. Report of the expert committee on the diagnosis and classification of diabetes mellitus. Diab Care 1997;20(7):1183–97.
[14] The expert committee on the diagnosis and classification of diabetes mellitus. Follow-up report on the diagnosis of diabetes mellitus. Diab Care 2003;26(11):3160–67.
[15] ACE/AACE consensus statement. Diagnosis and management of pre-diabetes in the continuum of hyperglycemia. Endo Pract 2008;14:933–46.
[16] Alberti KGMM, Zimmet P, Shaw J. International diabetes federation: a consensus on type 2 diabetes prevention. Diab Med 2007;24:451–63.
[17] Shaw JE, Zimmet PZ, De Courten M, Dowse GK, Chitson P, Gareeboo H, et al. Impaired fasting glucose or impaired glucose tolerance. What best predicts future diabetes in Mauritius? Diab Care 1999;22:399–402.
[18] Tominaga M, Eguchi H, Manaka H, Igarashi K, Kato T, Sekikawa A. Impaired glucose tolerance is a risk factor for cardiovascular disease, but not impaired fasting glucose. Diab Care 1999;22:920–4.
[19] Wong TY, Liew G, Tapp RJ, et al. Relation between fasting glucose and retinopathy for diagnosis of diabetes: three population based cross sectional studies. Lancet 2008;371:736–43 [erratum in Lancet 2008;371:1838].
[20] Haffner S, Cassells H. Hyperglycemia as a cardiovascular risk factor. Am J Med 2003;115(Suppl. 8A):6s–11S.
[21] Levitzky YS, Pencina MJ, D'Agostino RB, Meigs JM, Vasan RS, et al. Impact of impaired fasting glucose on cardiovascular disease: the Framingham heart study. J Am Coll Cardiol 2008;22:264–70.
[22] Fuller JH, Shipley MJ, Rose G, Jarrett RJ, Keen H. Coronary-heart-disease risk and impaired glucose tolerance. The Whitehall study. Lancet 1980;1:1373–6.
[23] Lowe LP, Liu K, Greenland P, Metzger BE, Dyer AR, Stamler J. Diabetes, asymptomatic hyperglycemia, and 22-year mortality in black and white men: the Chicago heart association detection project in industry study. Diab Care 1997;20:163–9.
[24] DECODE study group. The European diabetes epidemiology group. Glucose tolerance and cardiovascular mortality: comparison of fasting and 2-hour diagnostic criteria. Arch Int Med 2001;161:397–404.
[25] Nathan DM. Long-term complications of diabetes mellitus. NEJM 1993;328:1676–85.
[26] Kannel WB, McGee DL. Diabetes and cardiovascular disease. The Framingham study. JAMA 1979;241:2035–8.
[27] Khaw KT, Warcham N, Bingham S, Luben R, Welch A, Day N. Association of HbA1c with cardiovascular disease and mortality in adults: the European prospective investigation into cancer in Norfolk. Ann Int Med 2004;141:413–20.
[28] Danaei G, Lawes CMM, Vander Hoorn S, Murray CJL, Ezzati M. Global and regional mortality from ischaemic heart disease and stroke attributable to higher-than-optimum blood glucose concentration: comparative risk assessment. Lancet 2006;368:1651–9.
[29] Saydah S, Imperatore G, Tao M, Gregg E. GHb level and subsequent mortality among adults in the US. Diab Care 2009;32:1440–6.
[30] Dale AC, Midthjell K, Nilsen TI, Wiseth R, Vatten LJ. Glycaemic control in newly diagnosed diabetes patients and mortality from ischaemic heart disease: 20-year follow-up of the HUNT study in Norway. Eur Heart J 2009;30:1372–7.
[31] DCCT. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. NEJM 1993;329:977–86.
[32] UK prospective diabetes study [UKPDS] group. Intensive blood–glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes [UKPDS 33]. Lancet 1998;352:837–53.
[33] Stratton IM, Adler AI, Neil HAW, Matthews DR, Manley SE, Cull CA, et al. Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. BMJ 2000;321:405–12.
[34] Holman RR, Paul SK, Bethel MA, Matthews DR, Neil AW. 10-year follow-up of intensive glucose control in type 2 diabetes. NEJM 2008;359:1577–89.
[35] American diabetes association. Clinical practice recommendations 2009. Diab Care 2009;32(Suppl. 1):s1–94.
[36] Nathan DM. Glycemic management of type 2 diabetes. Arch Intern Med 2008;168:2064–6.
[37] The action to control cardiovascular risk in diabetes study group. Effects of intensive glucose lowering in type 2 diabetes. NEJM 2008;358:2545–59.
[38] The ADVANCE collaborative group. Intensive blood glucose control and vascular outcomes in patients with type 2 diabetes. NEJM 2008;358:2560–72.
[39] Goede P, Lund-Andersen H, Parving HH, Pederson O. Effect of a multifactorial intervention on mortality in type 2 diabetes. New Eng J Med 2008;358:580–91.
[40] US preventive services task force. Screening for type 2 diabetes mellitus in adults: US preventive services task force recommendation statement. Annals of Int Med 2008;148:846–55.
[41] Waugh N, Scotland G, McNamee P, Gillett M, Brennan A, Goyder E, et al. Screening for type 2 diabetes: literature review and economic modeling. Health Technol Assess 2007;11:1–125.
[42] Sheehy AM, Coursin DB, Gabbay RA. Back to Wilson and Jungner: 10 good reasons to screen for type 2 diabetes mellitus. Mayo Clin Proc 2009;84:38–42.
[43] Lawler FH. Reasons to exercise caution when considering a screening program for type 2 diabetes mellitus. Mayo Clin Proc 2009;84:34–6.
[44] Aldasouqi SA, Gossain VV. Revisiting screening for type 2 diabetes mellitus: to screen or not to screen, that is the question. Mayo Clin Proc 2009.
[45] Perry RC, Shankar RR, Finberg N, McGill J, Baron AD. HbA1c measurements improves the detection of type 2 diabetes in high-risk individuals with nondiagnostic levels of fasting plasma glucose: the early diabetes intervention program [EDIP]. Diab Care 2001;24:465–71.
[46] Bennett CM, Guo M, Dharmage SC. HbA1c as a screening tool for detection of type 2 diabetes: a systematic review. Diab Med 2007;24:333–43.
[47] Aldasouqi SA, Gossain VV. HbA1c: past, present and future. Ann Saudi Med 2008;28:411–9.
[48] Aldasouqi SA, Solomon D, Bokhari SA, Khan PM, Muneera S, Gossain VV. Glycohemoglobin A1c: A promising screening tool in gestational diabetes mellitus. Int J Diab Dev Ctries 2008;28(4):121–4.
[49] McCane DR, Hanson RL, Charles MA, Jacobsson LTH, Pettit D, Bennett PH, et al. Comparison of tests for gyrated haemoglobin and fasting and two hour plasma glucose concentrations as diagnostic methods for diabetes. BMJ 1994;308:1323–8.
[50] Saudek CD, Herman WH, Saeks DB, Bergenstal RM, Edelman D, Davidson MB. A new look at screening and diagnosing diabetes mellitus. J Clin Endocrinol Metab 2008;93:2447–53.
[51] American diabetic association. Professional section quarterly. Winter 2009. p. 1.
[52] Fachnie JD, Whitehouse FW, McGrath Z. Vomiting during OGTT in third trimester of pregnancy. Diab Care 1988;11:818.
[53] Artal R, Mosley GM, Doney FJ. Glycohemoglobin as a screening test for gestational diabetes. Am J Obstet Gynecol 1984;148:412–4.
[54] Morris MA, Grandis AS, Litton J. Glycosylated hemoglobin a sensitive indicator of gestational diabetes. Obstet Gynecol 1986;68:357–61.
[55] Shah BD, Cohen AW, May C, Gabbe SG. Comparison of glycohemoglobin determination and one hour glucose screen in identification of gestational diabetes. Am J Obstet Gynecol 1982;144:774–7.
[56] McFarland KF, Murtiashaw M, Baynes JW. Clinical value of glycosylated serum proteins and glycosylated hemoglobin levels in the diagnoses of gestational diabetes mellitus. Obstet Gynecol 1984;64:516–8.
[57] Cocilovo G, Guerra S, Coka F, Tomasi F. Glycosylated hemoglobin [HbA1] assay as a test for detection and surveillance of gestational diabetes. A reappraisal. Diab Metab 1987;13:426–30.
[58] Agarwal MM, Hughes PF, Punnose J, Ezimokhai M, Thomas L. Gestational diabetes screening of a multiethnic, high-risk population using glycated proteins. Diab Res Clin Pract 2001;51:67–73.
[59] Agarwal MM, Dhatt G, Punnose J, Koster G. Gestational diabetes: a reappraisal of HbA1c as a screening test. Acta Obstet Gynecol Scan 2005;84:1159–63.
[60] Simmons D, Rowan J, Reid R, Campbell N. On behalf of national GDM working party. Screening, diagnosis and services for women with gestational diabetes mellitus [GDM] in New Zealand: a technical report from the national GDM technical working party. New Zealand Med J 2008;121:74–85.