Early diabetes screening in women with previous gestational diabetes: a new insight

Aline Nabuco1,3*, Samara Pimentel1, Carolina A. Cabizuca1, Melanie Rodacki1, Denise Finamore2, Marcus M. Oliveira1 and Lenita Zajdenverg1

Abstract

Background: Gestational diabetes mellitus (GDM) is a risk factor for the development of diabetes mellitus (DM). However, there is a low return rate for this screening, so it is important to search for earlier methods for evaluation after delivery, to increase the number of pregnant women screened, so you can start the treatment or prevention of these early comorbidities. To determine the accuracy of the 75 g 2-h oral glucose tolerance test (OGTT) performed between 48–72 h after delivery for the diagnosis of DM using the OGTT after 6 weeks as the gold standard criterion, and to identify the optimal cutoff points for this exam for diabetes screening after a pregnancy complicated by GDM.

Methods: 82 women with previous GDM underwent an OGTT between 48–72 h postpartum and repeated the test 6 weeks after delivery.

Results: The prevalence of DM and prediabetes based on the first OGTT was 3.7 and 32.9 %, respectively, and 8.5 and 20.7 %, respectively, at the second OGTT. For those with DM, the area under the curve (AUC) based on the fasting plasma glucose (FPG) was 0.77 (95 % CI 0.61–0.92), and based on 2-h OGTT was 0.82 (95 % CI 0.66–0.97). For patients with prediabetes, the AUC based on the FPG was 0.73 (95 % CI 0.59–0.86) and based on the 2-h OGTT was 0.74 (95 % CI 0.61–0.87). Using a FPG cutoff value of 78 mg/dl (4.3 mmol/L) and a 2-h OGTT cutoff value of 130 mg/dl (7.2 mmol/L) for DM, the specificity was 58.7 and 60 %, the sensitivity was 71.4 and 85.7 %, the positive predictive value was 13.9 and 16.7 and the negative predictive value was 95.7 and 97.9 %, respectively.

Conclusions: OGTT performed early in postpartum is a useful tool for identifying women with previous GDM who must perform an OGTT 6 weeks after delivery.

Keywords: Gestational diabetes mellitus, Postpartum screening, Puerperium

Background

The number of patients with diabetes mellitus (DM) has increased significantly in recent decades. Despite better awareness and developments in treatment and prevention of type 2 diabetes, one in two adults with diabetes is undiagnosed [1]. The increasing prevalence of overweight and obesity in both developed and developing countries are the main factors for this rise [2]. Likewise, a growing number of cases of gestational diabetes mellitus (GDM) have been described in the last decades [3].

The frequency of GDM varies between 3–14 % depending on the method used for diagnosis and the study population [4–7]. The magnitude of the risk of postpartum diabetes depends on the ethnicity, the duration of follow up and the specific criteria for GDM diagnosis. Studies have shown that 3–65 % of women with previous GDM develop type 2 diabetes within 5–16 years after the index pregnancy [8–13]. When screened 6–12 weeks postpartum, up to 10 % of women who had GDM were diagnosed with diabetes and an additional 12–36 % had impaired fasting glucose or impaired glucose tolerance.
Postpartum screening aims to identify women that developed or have an elevated risk of developing diabetes after pregnancy. Early recognition is important because lifestyle modifications and medications can reduce the incidence of diabetes in individuals at high risk [16–18]. Additionally, the early treatment of diabetes can prevent or delay microvascular end organ complications and reduce the risk of experiencing complications in subsequent pregnancies [19–23].

Both the American Diabetes Association (ADA) and the World Health Organisation (WHO) recommend postpartum screening after 6–12 weeks, using the 75 g 2-h oral glucose tolerance test (OGTT) [24–26]. The United Kingdom’s National Institute for Health and Clinical Excellence (NICE) recommends the fasting plasma glucose (FPG) test be administered at least 6 weeks after childbirth, instead of the traditional OGTT [27, 28]. The OGTT is more sensitive, with reported sensitivities of 100 % compared with 67 % for the FPG [29]. Previous studies of postpartum diabetes screening in women with GDM-affected pregnancies have noted test completion rates that range from 14–61 % [15, 20, 30, 31]. Alternative diagnostic tools may increase the number of evaluated women with previous GDM. The ADA recommends that women with a history of GDM with a normal postpartum screening might be rescreened every 3 years, and women with impaired fasting glucose (IFG) or impaired glucose tolerance (IGT) or both (prediabetes) should be rescreened annually [18].

The purpose of this study was to determine the accuracy of the 2-h OGTT performed between 48–72 h after delivery for the diagnosis of diabetes and to identify the optimal 2-h OGTT cutoff points for screening dysglycaemia in the early postpartum period using the follow-up 2-h OGTT after 6 weeks as the gold standard criteria.

Methods
Study design
In this prospective observational study, women with previous GDM who were recruited from a multi-ethnic population were evaluated. The diagnosis of GDM in pregnant women prior to December 2010 was made according to the Carpenter and Coustan criteria [32]; after January 2011, the diagnosis was made according to the International Association of Diabetes and Pregnancy Study Groups (IADPSG) [33]. The inclusion criteria were pregnant women diagnosed with GDM with regular follow-up in the diabetes and pregnancy outpatient clinic of the maternity school at Rio de Janeiro Federal University. Women who used medications known to affect glucose metabolism, and mothers diagnosed with GDM who were discharged before 48 h after delivery were excluded (8.1 %). All women identified with GDM underwent self-monitoring of blood glucose measurements, as well as dietary management. Insulin treatment was initiated when dietary management did not achieve the glycaemic goal (fasting blood glucose >95 mg/dl, 1 h postprandial blood glucose >140 mg/dl, or 2 h postprandial blood glucose >120 mg/dl). The standard care was to screen all pregnant women with previous GDM with the 2-h OGTT at six weeks after delivery.

Data collection included a detailed clinical and obstetric history. Measurements of FPG and a 2-h OGTT were assessed using an enzymatic colorimetric method between 48–72 h and 6 weeks after delivery. Study subjects were instructed to fast overnight for at least 8 h prior to their testing day and to eat at least 150 g of carbohydrate the day prior to testing. The OGTT used a 75 g anhydrous glucose load and followed the standard WHO procedures [34]. The diagnostic categories of normal, prediabetes (i.e., impaired fasting glucose or impaired glucose tolerance) and diabetes were determined from the results of the FPG and 2-h OGTT using the WHO 2006/ADA criteria [35].

Ethical considerations
All participants provided written informed consent. The Local Ethics Committee approved this study.

Statistical analysis
Statistical analyses were performed with SPSS version 20.0. Differences in the classifications between normal, prediabetes and diabetes using the FPG and OGTT were assessed using a non-parametric test (Wilcoxon). Receiver operating characteristic (ROC) curves were developed, and the area under the curve (AUC) with 95 % CIs was determined. The ROC curves were constructed to calculate the sensitivity, specificity, predictive value positive and predictive value negative at different cutoff values. The optimal FPG and 2 h OGTT-screening cutoff points between 48–72 h after delivery were determined by taking the greatest sum of the sensitivity and specificity for the measured FPG and 2-h OGTT values between the two diagnosed groups (diabetes and prediabetes). The positive predictive value was defined as the number of true positives divided by the total number of individuals who tested positive, whereas the negative predictive value referred to the proportion of subjects with a negative test result who were correctly diagnosed. The positive predictive value and negative predictive value were also reported for the optimal cutoff values.

Results and discussion
During the inclusion period, 257 women with GDM were identified; however, only 82 (31.9 %) patients met all inclusion criteria, had full laboratory data for analysis,
and were included in the study. In fact, 21 mothers were discharged before 48 h (8.1 %), 49 patients did only the first OGTT (19 %), and 105 did not return to the second OGTT (40.85 %). Perinatal features of this study cohort were as follows: the mean age was 32.2 (± 5.8) years, the mean body mass index (BMI) was 27.7 (± 5.3) kg/m², 54.4 % were non-caucasian, 56.7 % had more than 8 years of education and 68.4 % had a relative with DM. Additionally, the mean parity of the women was 2.3 (± 1.3), the mean gestational age at GDM diagnosis was 23.1 weeks (± 7.4), 69.4 % had a caesarean delivery and 64.6 % required insulin treatment. The mean FPG levels in the early period (48–72 h) after delivery were 76.7 mg/dl (4.26 mmol/L ± 0.66), whereas the mean FPG levels after 6 weeks were 92.6 mg/dl (5.1 mmol/L ± 15.7) (p < 0.0001). All patients were breastfeeding during routine postpartum OGTT. The 2 h post-load glucose was 123.6 mg/dl (6.8 mmol/L ± 2.0) and 110.0 mg/dl (6.1 mmol/L ± 2.2) (p = 0.001) between 48–72 h and after 6 weeks, respectively. The prevalence of diabetes and prediabetes based on the 75 g OGTT performed at 48–72 h after birth was 3.7 and 32.9 %, respectively, whereas the prevalence based on the second OGTT was 8.5 and 20.7 %, respectively.

Women with diagnosis of diabetes on the second 75 g OGTT (n = 7) had mean age of 33.1 (± 6.4) years and the mean BMI was 29.8 (± 7.2) kg/m² respectively. In addition, the mean parity was 2.4 (± 1.6), and the mean gestational age at GDM diagnosis was 19.4 (± 8.7). These patients had a mean weight gain until the GDM diagnosis of 5.1 (± 3.8) kg and 8.2 (± 2.9) kg until delivery. Eighty-five percent were on using insulin at an average of 27.3 (± 2.9) weeks, and seventy-one percent had a family history of DM. The delivery was on average 37.5 (± 5.2) weeks and the neonate’s weight was 3108.3 (± 957.2) g. There was no statistically significant difference between mothers with and without a diagnosis of diabetes postpartum.

Using the 2-h value of 200 mg/dl (11.1 mmol/L) as the cutoff for identifying individuals with diabetes resulted in a sensitivity of 28.6 %, a specificity of 98.7 % and positive and negative predictive values of 66.7 and 93.7 %, respectively. The performance of the early 2-h OGTT was also evaluated using 140 mg/dl (7.7 mmol/L) as the cutoff for identifying individuals with prediabetes, which revealed a sensitivity of 64.7 %, a specificity of 75.4 % and positive and negative predictive values of 40.7 and 89.1 %, respectively.

The AUC based on the FPG in the early period for the group with diabetes was 0.77 (95 % CI 0.61–0.92; p = 0.020) and 0.82 (95 % CI 0.66–0.97; p = 0.006) based on the 2-h OGTT (Fig. 1). The AUC based on the FPG in the early period for the group with prediabetes was 0.73 (95 % CI 0.59–0.86 p = 0.004) and 0.74 (95 %CI 0.61–0.87; p = 0.002) based on the 2-h OGTT (Fig. 1). The greatest accuracy for prediabetes was found with the cutoff values of 78 mg/dl (4.3 mmol/L) for FPG and 130 mg/dl (7.2 mmol/L) for the 2-h OGTT (specificity was 63.1 and 64.6 %, sensitivity was 70.6 and 76.5 %, the positive predictive value was 33.3 and 36.1 % and the negative predictive value was 89.1 and 91.3 %, respectively). The greatest accuracy for diabetes was found with the cutoff values of 80 mg/dl (4.4 mmol/L) for the FPG and 150 mg/dl (8.3 mmol/L) for the 2-h OGTT (the specificity was 66.7 and 80 %, the sensitivity was 71.4 % for both, the positive predictive value was 16.7 and 25 % and the negative predictive value was 96.2 and 96.8 %, respectively) (Table 2).

The mean age of women not included in the study (n = 175) were 30.5 (± 5.8) years and the mean age of pregnancy at GDM diagnosis were 23.9 (± 7.4) weeks, with an average BMI of 28.4 (± 5.1) kg/m². In addition,

| Table 1 Patient characteristics |
|--------------------------------|
| Characteristics | Mean ± SD or % |
| Age (years) | 32.2 ± 5.8 |
| Gestational age at diagnosis (weeks) | 23.1 ± 7.4 |
| Parity (n) | 2.3 ± 1.3 |
| Weight gain until delivery (kg) | 10.2 ± 6.3 |
| Pre-pregnancy BMI (kg/m²) | 27.7 ± 5.3 |
| Gestational age at birth (weeks) | 37.8 ± 2.9 |

Fig. 1 Receiver operating characteristics curve for the FPG and 2 h OGTT used for the detection of diabetes by glucose criteria. a Early FPG for DM. b Early 2-h OGTT for DM. c Early FPG for Pre DM. d Early 2-h OGTT for Pre DM.
57.5% were on insulin and 65.4% had a family history of diabetes. Comparing both groups (women included and not included in the study), there was no statistically difference in continuous sociodemographic variables. Concerning the categorical variables, the history of previous GDM in the mothers included in the study was significantly higher than in the group of mothers not included (23.4% × 7.9%, \( p = 0.008 \)). There was no significant difference in other categorical variables between the two groups (Tables 3, 4).

We compared the influence of the type of delivery (Vaginal vs Cesarean section) on serum levels of fasting glucose and post-load 75 g, both in collecting 48–72 h as in collecting six weeks, and no statistically significant difference was found.

**Discussion**

To our knowledge, this is the first study that evaluate the accuracy and cut off values of OGTT during the early postpartum period in women still hospitalised with previous GDM for determine DM risk. Recently, a study was published and evaluated 58 women with previous GDM who agreed to perform the 75 g OGTT on the second day postpartum. These results were compared with the standard 75 g OGTT 4–12 weeks postpartum. Only 49 of the 98 women presented for routine postpartum OGTT. This study concludes that performing OGTT on the second day is feasible and should be further investigated as an alternative postpartum testing regimen in GDM [36]. In women who do not breastfeed, prolactin returns to pre-pregnancy levels by 3 weeks after delivery [46]. These hormones, which are counter-regulatory to insulin, contribute to increased insulin resistance in the early postpartum period. Although the OGTT at 48–72 h did not appear to define the diagnosis of diabetes in this study, it was notable that the OGTT at 48–72 h had a high negative predictive value, with a cutoff FPG <78 mg/dl (4.3 mmol/L) and 2-h OGTT <130 mg/dl (7.2 mmol/L), thereby excluding nearly all individuals with diabetes (but not prediabetes). Moreover, diabetes-screening cutoffs that included an early FPG of 78 mg/dl (4.3 mmol/L) and a 2 h OGTT of 130 mg/dl (7.2 mmol/L) effectively identified higher-risk individuals who required a referral for additional evaluation and management. Using these cutoff points, it was found that only 37% of women should be advised to have their glucose tolerance assessed 6 weeks after delivery. Thus, more than half of women (63%) should be reevaluated only after 1–3 years per the ADA guidelines on the frequency of testing [18]. Furthermore, identifying women that should return at 6 weeks eases the overall burden to health-care practitioners and reduces the effort required to contact patients and, if necessary, provide a home visit by a health-care worker, which many studies have recommended [47].

| Table 2 Optimal early fasting glucose and 2-h OGTT for the determination of dysglycaemia |
|-----------------------------------------------|-----------------------------------------------|
| Receiver operating curve cutoff value (fasting and post-prandial glucose) (mg/dl) | AUC (95% CI) | Sensitivity (%) | Specificity (%) | Positive predictive value (%) | Negative predictive value (%) |
| Prediabetes 78 | 0.73 (0.59–0.86) | 70.6 | 63.1 | 33.3 | 89.1 |
| Prediabetes 130 | 0.74 (0.61–0.87) | 76.5 | 64.6 | 36.1 | 91.3 |
| Diabetes 130 | 0.82 (0.66–0.97) | 85.7 | 60.0 | 16.7 | 97.8 |
| Diabetes 150 | 0.82 (0.66–0.97) | 71.4 | 80.0 | 25 | 96.8 |
| Diabetes 78 | 0.77 (0.61–0.91) | 71.4 | 58.7 | 13.9 | 95.7 |
| Diabetes 80 | 0.77 (0.61–0.91) | 71.4 | 66.7 | 16.7 | 96.2 |
The possibility of performing the screening while women are still in the hospital will most likely enhance the efficacy of detecting women at a higher risk for developing DM and will reinforce the need to return for individuals with a greater risk. Hospital sampling could overcome the barriers that currently prevent women from returning to health-care providers for investigation after 6 weeks. The characteristics of patients associated with higher rates of postpartum screening included older age, nulliparity, and higher income or education [15, 31]. Women who received prenatal care, were treated with insulin during pregnancy, or completed a postpartum visit were also more likely to receive a postpartum diabetes screening [15]. In the present study, 31.9 % of the women attended the postpartum follow-up examination, although all patients received reminders upon completion of the first OGTT. This response rate is similar to the lowest follow-up frequency [15, 31]. The most likely explanation for this result is that women in the studied population predominately belonged to low socioeconomic levels and thus, had lower levels of income and education. Sixty-four percent of patients that were included required insulin treatment, and 56 % of patients had more than 8 years of education. The problem of identifying DM after GDM, which may be of greater concern than the choice of test itself, is the poor postpartum screening rate. Although counselling for the management of chronic disease may be challenging in the postpartum period, individuals sometimes express greater interest in their health during times of illness, and opportunities for early diagnosis should not be lost. During a brief discussion, patients with elevated FPG and/or 2 h OGTT could be encouraged to partner with a provider and maintain long-term care, as well as to attempt lifestyle modifications. The concept of a “teachable moment” has been demonstrated for the case of smoking cessation, in which patients are more likely to quit smoking after health events, such as pregnancy, hospitalisation, and the diagnosis of cancer [39]. Thus, health events represent opportunities for health care providers to educate patients and encourage behaviour modifications [48–50].

The prevalence of diabetes in women after GDM in our study (8.5 %) is consistent with those previously described (5–14 %) [14, 15, 51–53]. The first OGTT identified more prediabetes than diabetes cases compared with the second OGTT (prediabetes 32.9 vs 20.7 %; DM 3.7 vs 8.5 %). This result was most likely the result of the number of patients included. Larger cohorts are necessary to recommend the OGTT at 48–72 h as a test for the early screening of postpartum women with GDM. Differences may also result from interference related to the hormonal changes that occur during this postpartum period [37–39]. A special hormonal milieu is observed between 48–72 h after birth. During pregnancy, the levels of oestrogen and progesterone increase greatly primarily because of placental production [40–43]. Following the removal of the placenta, these hormones fall sharply and reach pre-pregnancy levels by 3 weeks after delivery [46]. These hormones, which are counter-regulatory to insulin, contribute to increased insulin resistance in the early postpartum period.

This study had some limitations. Firstly, patients were included since 2008 and were classified according to two different criteria for GDM diagnosis (Carpenter

| Table 3 Comparison of sociodemographic categorical variables of pregnancy and the newborn among the women included and not included in the study | Included (%) | Not included (%) | P value |
|---|---|---|---|
| Age (years) | 0.085 | | |
| 10–20 | 0 | 5.26 | |
| 21–30 | 40.5 | 43.4 | |
| 31–40 | 50.6 | 48.7 | |
| 41–50 | 8.9 | 2.6 | |
| Ethnicity | 0.86 | | |
| Caucasian | 45.6 | 47.1 | |
| Non caucasian | 54.4 | 52.9 | |
| Gestational age at DMG diagnosis (weeks) | 0.56 | | |
| ≤20 | 38.0 | 33.7 | |
| ≥21 | 62.0 | 66.3 | |
| Insulin treatment | 0.35 | | |
| Yes | 64.6 | 57.5 | |
| No | 35.4 | 42.5 | |
| Previous history of DMG | 0.008 | | |
| Yes | 23.4 | 7.9 | |
| No | 76.6 | 92.1 | |
| BMI (kg/m²) | 0.46 | | |
| <25 | 34.7 | 26.9 | |
| 25–29.9 | 31.9 | 39.7 | |
| 30–34.9 | 25.0 | 19.2 | |
| 35–40 | 8.3 | 12.8 | |
| >40 | 0.0 | 1.3 | |
| Macrosomia | 0.17 | | |
| Yes | 14.9 | 24.5 | |
| No | 85.1 | 75.5 | |
| Type of delivery | 0.14 | | |
| Vaginal | 30.7 | 18.2 | |
| Caesarean | 69.4 | 81.8 | |
| DM familiar | 0.69 | | |
| Yes | 68.4 | 65.4 | |
| No | 31.6 | 34.6 | |
and Coustan and the IADPSG). Ikenoue et al. suggested that the IADPSG-defined GDM of one abnormal OGTT value indicates a less severe glucose intolerance, but may still signal a risk of requiring insulin when a first-degree family history of diabetes exists [54]. Our participants had a high prevalence of a relative with diabetes (68.4%). Moreover, women who were discharged prior to 48 h were not included in this study. These patients most likely had a milder case of GDM and lowest prevalence of postpartum DM. Additionally, the sample size is small, therefore the 95% CIs around the AUROC curves are quite wide.

Indeed, curtailing the rapidly increasing prevalence of early-onset diabetes is a formidable task for health-care practitioners. Additional efforts are necessary to identify these young women as early as possible because they are one of the best groups for which the implementation of a primary prevention strategy is most effective, not only for themselves but also for their offspring and family. Early postpartum screening for DM effectively identifies higher-risk women with previous GDM who require a referral for additional evaluation and management.

Conclusions
OGTT performed early in postpartum is a useful tool for identifying women with previous GDM who must perform an OGTT 6 weeks after delivery. A diabetes-screening cutoff of FPG of 78 mg/dl (4.3 mmol/L) and a 2-h OGTT of 130 mg/dl (7.2 mmol/L) effectively identified higher-risk individuals who require a referral for additional evaluation and should be further assessed in larger prospective studies.

Abbreviations
ADA: American Diabetes Association; AUC: area under the curve; BMI: body mass index; DM: diabetes mellitus; FPG: fasting plasma glucose; GDM: gestational diabetes mellitus; IFG: impaired fasting glucose; IGT: impaired glucose tolerance; IADPSG: International Association of Diabetes and Pregnancy Study Groups; OGTT: oral glucose tolerance test; ROC: receiver operating characteristic; NICE: United Kingdom’s National Institute for Health and Clinical Excellence; WHO: World Health Organisation.

Table 4 Comparison of sociodemographic continuous variables of pregnancy and the newborn among women included (n = 82) and not included (n = 175) in the study

| Variable                                      | Included Mean ± SD | Included Median | Not included Mean ± SD | Not included Median | P value |
|-----------------------------------------------|--------------------|-----------------|------------------------|---------------------|---------|
| Age (years)                                   | 32.2 ± 5.8         | 32              | 30.5 ± 5.8             | 31                  | 0.075   |
| Gestational age at diagnosis of GDM (weeks)   | 23.1 ± 7.4         | 24              | 23.9 ± 7.4             | 25                  | 0.47    |
| Start of insulin (weeks)                      | 28.6 ± 7.1         | 30              | 26.9 ± 7.2             | 28                  | 0.30    |
| Parity (n)                                    | 2.3 ± 1.3          | 2               | 2.3 ± 1.4              | 2                   | 0.89    |
| Weight gain until GDM diagnosis (kg)          | 7.0 ± 5.5          | 6               | 8.0 ± 5.6              | 8.8                 | 0.18    |
| Weight gain until delivery (kg)               | 10.2 ± 6.3         | 8.2             | 11.6 ± 6.0             | 11.5                | 0.23    |
| Pregestational BMI (kg/m²)                    | 27.7 ± 5.3         | 27.1            | 28.4 ± 5.1             | 27.6                | 0.41    |
| Birth weight (kg)                             | 3250.3 ± 627.3     | 3257.5          | 3409.2 ± 652.0         | 3400                | 0.21    |
| Gestational age at delivery (weeks)           | 37.8 ± 2.9         | 38              | 37.8 ± 2.0             | 38                  | 0.32    |

Authors’ contributions
AN contributed in the study implementation, analysis and interpretation of data and major contribution to writing drafted the manuscript. MR drafted the manuscript. CAC, DF and MO contributed in the study implementation. LZ contributed in the study design, study implementation, analysis and interpretation of data and writing drafted the manuscript. All authors read and approved the final manuscript.

Author details
1 Nurology and Diabetes Section/Maternidade Escola, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; 2 Materinidade Escola, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; 3 Serviço de Nurologia e Diabetes, Hospital Universitário Clementino Fraga Filho, Rua Professor Rodolpho Paulo Rocco 255, sala 9E14, University City CEP 21941-913, Brazil.

Acknowledgements
We would like to thank Tatiana Barcelos for helping with the collection of laboratory tests.

Competing interests
The authors declare that they have no competing interests.

Funding
This study was funded by Maternidade Escola, Federal University of Rio de Janeiro.

Received: 29 December 2015 Accepted: 18 July 2016
Published online: 27 August 2016

References
1. International Diabetes Federation. IDF Diabetes Atlas, 7th edn. Brussels, Belgium: International Diabetes Federation, 2015. http://www.diabetesatlas.org.
2. Caprio S. Development of type 2 diabetes mellitus in the obese adolescent: a growing challenge. Endocr Pract. 2012;18:791–5.
3. Ferrara A. Increasing prevalence of gestational diabetes mellitus: a public health perspective. Diabetes Care. 2007;30 Suppl 2:S141–6.
4. Reichelt AJ, Spichler ER, Brandtkein L. Fasting plasma glucose is a useful test for the gestational diabetes. Diabetes Care. 1998;21:1246–9.
5. Bowes SB, Hennessy TR, Umpleby AM. Measurement of glucose metabo-
   lism and insulin secretion during normal pregnancy and pregnancy
   complicated by gestational diabetes. Diabetologia. 1996;39:976–83.
6. O’Sullivan JB, Mahan CM, Charles D, Dandrow RV. Screening criteria for high-
   risk gestational diabetic patients. Am J Obstet Gynecol. 1973;116:895–900.
7. American Diabetes Association. Clinical practice recommendations. 1996.
   Diabetes Care. 1996;19(Suppl 1):111–18.
8. Philippson EH, Super DM. Gestational diabetes mellitus: does it recur in
   subsequent pregnancy? Am J Obstet Gynecol. 1989;160:1324–31.
9. Gaudier FL, Hauth JC, Post M, Corbett DL, Cliver SP. Recurrence of gesta-
   tional diabetes mellitus. Obstet Gynecol. 1992;80:755–8.
10. Coellingh Bennink H.T. Recurrence of gestational diabetes. Eur J Obstet
    Gynecol Reprod Biol. 1977;1:359–63.
11. Grant PT, Oats JN, Beischer NA. The long-term follow-up of women with
    gestational diabetes. Aust N Z J Obstet Gynaecol. 1986;26:17–22.
12. Moses RG. The recurrence rate of gestational diabetes in subsequent
    pregnancies. Diabetes Care. 1996;19:1348–50.
13. Damm P. Gestational diabetes mellitus and subsequent development of
    overt diabetes mellitus. Dan Med Bull. 1998;45:495–509.
14. Centers for Disease Control and Prevention. National diabetes fact sheet:
    national estimates and general information on diabetes and prediabetes
    in the United States, 2011. Atlanta: US Department of Health and Human
    Services, Centers for Disease Control and Prevention; 2011. http://www.
    cdc.gov/diabetes/pubs/pdf/ndss11.pdf
15. Tovar A, Chasan-Taber L, Eggleston E, Oken E. Postpartum screening for
    diabetes in women with a history of gestational diabetes mellitus.
    Prev Chronic Dis. 2011;8:A124.
16. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker
    EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle
    intervention or metformin. N Engl J Med. 2002;349:393–403.
17. American Diabetes Association. Diagnosis and classification of diabetes
    mellitus. Diabetes Care. 2007;30(Suppl 1):S42–7.
18. Metzger BE, Buchanan TA, Coustan DR, de Leiva A, Dunger DB. Summary
    and recommendations of the Fifth International Workshop Confer-
    ence on gestational diabetes mellitus. Diabetes Care. 2007;30 Suppl 2:S251–60.
19. The Diabetes Control and Complications Trial/Epidemiology of Diabetes
    Interventions and Complications Research Group. Retinopathy and
    nephropathy in patients with type 1 diabetes four years after a trial of
    intensive therapy. N Engl J Med. 2000;342:381–9.
20. Ratner R. Prevention of type 2 diabetes in women with previous gesta-
    tional diabetes. Diabetes Care. 2007;30:242–5.
21. Chalmers J, Cooper M. UKPDS and the legacy effect. N Engl J Med.
    2008;359:1618–20.
22. UK Prospective Diabetes Study Group. Intensive blood-glucose control
    with sulphonylureas or insulin compared with conventional treatment
    and risk of complication in patients with type 2 diabetes (UKPDS33).
    Lancet. 1998;352:837–53.
23. The Diabetes Control and Complications Trial/Epidemiology of Diabetes
    Interventions and Complications Research Group. Intensive diabetes
    treatment and cardiovascular disease in patients with type 1 diabetes. N
    Engl J Med. 2005;353:2643–53.
24. American Diabetes Association. Gestational diabetes mellitus (position
    statement). Diabetes Care. 2004;27(1 Suppl 1):S88–90.
25. The Expert Committee on the Diagnosis and Classification of Diabetes
    Mellitus. Report of the Expert Committee on the Diagnosis and Classifica-
    tion of Diabetes Mellitus. Diabetes Care. 1997;20:1183.
26. World Health Organisation. Definition, diagnosis and classification of
    diabetes and its complications. Report of a WHO consultation. Part 1:
    diagnosis and classification of diabetes mellitus. Geneva: WHO; 1999.
27. Nice guideline. 2015. http://www.nice.org.uk/guidance/ng3.
28. World Health Organisation. Definition, diagnosis and classification of diabetes
    mellitus and intermediate hyperglycaemia. Geneva: WHO; 2006.
29. Wender EF, Has P, Tarabulli G, Lee J, Satin A. Early postpartum glucose
    testing in women with gestational diabetes mellitus. Am J Perinatol.
    2016;33(10):966–71. doi:10.1055/s-0036-1583193
30. Xiang A, Kjos S, Takayanagi M, Tringe E, Buchanan T. Detailed physi-
    ological characterization of the development of type 2 diabetes in
    Hispanic women with prior gestational diabetes mellitus. Diabetes.
    2010;59:2625–30.
31. Handwerger S, Freemark M. The roles of placental growth hormone
    and placental lactogen in the regulation of human fetal growth and develop-
    ment. J Pediatr Endocrinol Metab. 2000;13:343–56.
32. Metzger BE, Gabbe SG, Persson B, et al. International Association of
    diabetes and pregnancy study groups recommendations on the diag-
    nosis and classification of hyperglycemia in pregnancy. Diabetes Care.
    2010;33:676–82.
33. World Health Organisation Expert Committee on Diabetes Mellitus.
    Diabetes mellitus. Geneva: World Health Organisation; 1985.
34. World Health Organisation. Definition and diagnosis of diabetes mellitus
    and intermediate hyperglycaemia. Geneva: WHO; 2006.
35. Tovar A, Chasan-Taber L, Eggleston E, Oken E. Postpartum screening for
    diabetes in women with a history of gestational diabetes mellitus.
    Prev Chronic Dis. 2011;8:A124.
36. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker
    EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle
    intervention or metformin. N Engl J Med. 2002;349:393–403.
37. Diabetes Control and Complications Trial/Epidemiology of Diabetes
    Interventions and Complications Research Group. Retinopathy and
    nephropathy in patients with type 1 diabetes four years after a trial of
    intensive therapy. N Engl J Med. 2000;342:381–9.
38. Ratner R. Prevention of type 2 diabetes in women with previous gesta-
    tional diabetes. Diabetes Care. 2007;30:242–5.
39. Chalmers J, Cooper M. UKPDS and the legacy effect. N Engl J Med.
    2008;359:1618–20.
40. UK Prospective Diabetes Study Group. Intensive blood-glucose control
    with sulphonylureas or insulin compared with conventional treatment
    and risk of complication in patients with type 2 diabetes (UKPDS33).
    Lancet. 1998;352:837–53.
41. The Diabetes Control and Complications Trial/Epidemiology of Diabetes
    Interventions and Complications Research Group. Intensive diabetes
    treatment and cardiovascular disease in patients with type 1 diabetes. N
    Engl J Med. 2005;353:2643–53.
42. American Diabetes Association. Gestational diabetes mellitus (position
    statement). Diabetes Care. 2004;27(1 Suppl 1):S88–90.
43. The Expert Committee on the Diagnosis and Classification of Diabetes
    Mellitus. Report of the Expert Committee on the Diagnosis and Classifica-
    tion of Diabetes Mellitus. Diabetes Care. 1997;20:1183.
44. World Health Organisation. Definition, diagnosis and classification of diabetes
    and its complications. Report of a WHO consultation. Part 1:
    diagnosis and classification of diabetes mellitus. Geneva: WHO; 1999.
45. Nice guideline. 2015. http://www.nice.org.uk/guidance/ng3.
46. World Health Organisation. Definition, diagnosis and classification of diabetes
    mellitus and intermediate hyperglycaemia. Geneva: WHO; 2006.
47. Silverman RA, Thakker U, Ellman T, Wong I, Smith K, Ito K, Graff H. Kemo-
    globin A1c as a screen for previously undiagnosed prediabetes and diabetes
    in acute-care setting. Diabetes Care. 2011;34:1908–12.
48. Goor AA, Phelan S, Hill JO, Wing RR. Medical triggers are associated
    with better short- and long-term weight loss outcomes. Prev Med.
    2004;39:612–6.
49. Kim C, Newton KM, Knopp RH. Gestational diabetes and the incidence of type
    2 diabetes: a systematic review. Diabetes Care. 2002;25(10):1862–8.
50. Moreno Gutiérrez G, Macias Rocha AL, Puente Alvarez EI. Prevalence
    of postpartum impaired glucose tolerance after gestational diabetes.
    Ginecol Obstet Mex. 2010;38(10):631–5.
51. Anderberg E, Landén-Olsson M, Kälten J, Frid A, Ursing D, Berntorp K. Preva-
    lence of impaired glucose tolerance and diabetes after gestational diabetes
    mellitus comparing different cut-off criteria for abnormal glucose tolerance
    during pregnancy. Acta Obstet Gynecol Scand. 2011;90(11):1252–8.
    doi:10.1111/j.1600-0412.2011.01214.x (Epub Aug 29 2011)
52. Ikehoue S, Miyakoshi K, Sasho Y, et al. Clinical impact of women with
    gestational diabetes mellitus by the new consensus criteria: two-year
    experience in a single institution in Japan. Endocr J. 2014;61:353–8.