Gestational Diabetes

Gestational diabetes mellitus (GDM) is one of the most common clinical issues facing obstetricians and their patients. A lack of data from well-designed studies has contributed to the controversy surrounding the diagnosis and management of this condition. The purpose of this document is to provide a brief overview of our understanding of GDM and provide management guidelines that have been validated by appropriately conducted clinical research. When outcomes-based research is not available, expert opinion is provided to aid the practitioner.

Background

Definition and Prevalence

Diabetes is classified as type 1 or type 2 according to whether the patient requires insulin injections to avoid ketoacidosis. Gestational diabetes mellitus has been characterized as carbohydrate intolerance that begins or is first recognized during pregnancy. The prevalence of GDM varies in direct proportion to the prevalence of type-2 diabetes in a given population or ethnic group. Reported prevalence in the United States ranges from 1% to 14%, with 2–5% being the most common figure (1).

Maternal and Fetal Complications

Women with GDM are more likely to develop hypertensive disorders than women without GDM (2). Some of this additional risk may be related to the underlying risk factors for GDM (eg, increased maternal age and obesity). The diagnosis of GDM may prompt health care providers to intervene more readily for perceived problems (3). In women without GDM, there is a significant association between increasing carbohydrate intolerance and both preeclampsia and cesarean delivery (4). Women with GDM in Korea have a higher incidence of preeclampsia and primary cesarean delivery, yet only 10% of the women are obese (5). Whether the relationship with GDM is causal or not, clinicians...
should be aware of these risks. In addition, women with GDM have an increased risk of developing diabetes later in life.

The offspring of women with GDM are prone to such adverse events as macrosomia with its potential complications and hyperbilirubinemia. Infants of women with GDM are at increased risk for operative delivery, shoulder dystocia, and birth trauma. Because the risk factors for GDM (particularly obesity) are independent risk factors for fetal macrosomia, the role of maternal hyperglycemia has been widely debated. Although controlling for maternal obesity eliminated the apparent relationship between hyperglycemia and macrosomia in some studies (6, 7), these results may have been confounded because the women with GDM were treated. The relationship between GDM, fetal macrosomia, and other adverse outcomes has been confirmed in cohort studies in which maternal obesity and other potential confounders were controlled (8, 9), in a study of Korean women among whom only 10% were obese (5), and in another study of women whose abnormal glucose tolerance tests (GTTs) went clinically unrecognized (10). In women without GDM, there is an independent relationship to fetal macrosomia (4, 11). When data were corrected for maternal weight, age, parity, and race, the 12% risk of macrosomia was independently attributable to GDM (9). A number of studies also have linked maternal hyperglycemia with long-term obesity and diabetes in the offspring (12–14). Nevertheless, considerable controversy remains regarding the exact relationship of these complications to maternal hyperglycemia.

Controversy of Current Screening Practices and Treatment Benefits

At one time, screening for GDM consisted of taking the patient’s history. In 1973, O’Sullivan and Mahan proposed the 50-g, 1-hour laboratory screening test. This test has become widely used—94% of obstetric groups surveyed reported universal testing (15)—despite the absence of data to demonstrate a benefit to the population as a whole. However, as noted previously, maternal hyperglycemia is related to at least some of the adverse perinatal outcomes seen with GDM. Available evidence does not support the concept that women with GDM who do not have risk factors are of less concern than are those who do (16).

The use of traditional historic risk factors (family or personal history of diabetes, previous adverse pregnancy outcome, glycosuria, obesity) to identify GDM will miss approximately half of women with GDM (17, 18). If the risks of adverse outcomes are related to the presence or absence of confounding risk factors, rather than the GDM, then limited screening based on risk may be reasonable. The U.S. Preventive Services Task Force has concluded that although there is insufficient evidence to recommend universal screening, screening high-risk women may be beneficial (19).

Despite the lack of population-derived data supporting the benefit of making the diagnosis of GDM, clinical recommendations often must be made without unassailable epidemiologic evidence. Older, admittedly flawed, studies suggested an increased perinatal mortality rate among undiagnosed or untreated women with GDM (20, 21). More recent studies that did not demonstrate an increase in perinatal mortality risk all included interventions of diet or insulin, antepartum testing, or merely making the diagnosis, which has been shown to be a powerful intervention in and of itself (3). If the perinatal mortality rate in undiagnosed and untreated GDM were double the background rate, as suggested in earlier studies, and GDM occurs in 2–5% of the population, any increase in overall perinatal loss attributable to discontinuing screening programs would likely go unnoticed.

Another important issue to consider is the possibility that some patients diagnosed with GDM may have preexisting type-2 diabetes, which can only be confirmed postpartum. One study found such patients to have a perinatal mortality rate 6 times higher than those with milder forms of GDM (22). Another study found mothers with GDM who had infants with birth defects were more likely to have high fasting glucose values, suggesting the presence of undiagnosed preexisting diabetes (23).

For the population to benefit from the diagnosis of GDM, there should be an effective treatment for the condition. Although a number of comparative studies of various treatments are available, there is little information regarding the effectiveness of treatment versus no treatment. In a pilot randomized trial comparing strict metabolic control with routine obstetric care in 300 women with GDM, there was no difference in the rate of macrosomia or other pregnancy outcomes (24). However, even the control subjects monitored their own glucose levels 1 day each week, and 10% were removed from the study and treated for hyperglycemia.

The first consideration in selecting a therapy for GDM is a determination of the treatment goals. Although the degree, if any, of excess perinatal mortality associated with milder GDM has not been established, management plans typically include some type of fetal surveillance. A second goal of treatment may be the prevention of adverse pregnancy outcomes, such as macrosomia and its attendant consequences of operative delivery, shoulder dystocia, and birth trauma. Potential treatments toward this goal include diet, exercise, and insulin; oral agents also have been suggested. Safety,
efficacy, and patient acceptance should be considered in choosing a treatment.

The goal of treatment is to lower the likelihood of macrosomia and its consequences; neonatal hypoglycemia also may be reduced (25). Although the quality of the information varies, evidence is available to confirm these benefits. However, there has been no demonstrated treatment benefit on long-term outcomes for the offspring such as obesity and the development of diabetes. It should be emphasized that although the evidence is inconclusive that treating GDM can prevent maternal and fetal complications, universal screening and treatment are widely practiced.

Clinical Considerations and Recommendations

How should screening for GDM be accomplished?

All pregnant patients should be screened for GDM, whether by patient’s history, clinical risk factors, or a laboratory screening test to determine blood glucose levels. The optimal method of screening is controversial, and there are insufficient data from which to draw firm conclusions.

A number of clinical risk factors have been demonstrated to be associated with an increased likelihood of GDM, including age, ethnicity, obesity, family history of diabetes, and past obstetric history (26). In one study, more than 3,000 pregnant women underwent both the 50-g, 1-hour screening test and the diagnostic oral GTT (27). Using a complex scoring system of weighted risk factors, the study found test thresholds for the 1-hour screening test varied depending on individual risk status. Sensitivity rates were similar to those of universal screening, and there are insufficient data from which to draw firm conclusions.

Specific risk factors and the degree of their influence on GDM prevalence are difficult to quantify across populations. For example, in one Canadian study, African race was not associated with an increased risk of GDM (27), whereas in another large, observational study African race was found to be an independent predictor of the likelihood of GDM, even when investigators controlled for obesity (28). Because no single study can be generalized to the entire population, it seems reasonable to base the definition of high and low risk for GDM on the prevalence of type-2 diabetes in each ethnic group. The relationship between obesity and GDM is most likely a continuum, so that the definition of the upper limit of normal weight suggested by the Institute of Medicine (ie, a body mass index ≤25) (29) should reasonably serve to identify individuals who are not obese. A low-risk individual meets all of the following criteria (30):

1. Age younger than 25 years
2. Not a member of an ethnic group with an increased risk for the development of type-2 diabetes (examples of high-risk ethnic groups include women of Hispanic, African, Native American, South or East Asian, or Pacific Islands ancestry)
3. Body mass index of 25 or less
4. No previous history of abnormal glucose tolerance
5. No previous history of adverse obstetric outcomes usually associated with GDM
6. No known diabetes in first degree relative

When the 1997 criteria, similar to those listed previously for low risk, were applied to data from more than 18,000 pregnancies in a predominantly Caucasian population, researchers determined that only 3% of women with GDM would not have been diagnosed (31). However, only 10% of the population would have been exempted from screening. For this reason, many physicians elect to screen all pregnant patients as a practical matter.

At what gestational age should laboratory screening be performed?

A number of studies have demonstrated that the prevalence of GDM increases with advancing gestation (32–36). It has been customary to recommend the 50-g, 1-hour oral glucose challenge test be administered at 24–28 weeks of gestation. This arbitrary recommendation results from an attempt to balance two competing interests. Insulin resistance increases as pregnancy progresses, therefore, testing later in pregnancy will result in a higher yield of abnormal tests. However, the later the abnormality is diagnosed, the less time will be available for intervention. Although many practitioners choose to screen high-risk patients early in pregnancy, the benefit of early treatment of women with GDM identified early in pregnancy has not been demonstrated but rather has been accepted on a theoretical basis.

Patients who had GDM in a previous pregnancy have a 33–50% likelihood of recurrence in a subsequent pregnancy.
pregnancy (37–39). If such patients were not tested between pregnancies, some of these recurrences may represent preexisting diabetes undetected between pregnancies. In such individuals there should still be a benefit to making the diagnosis of diabetes during the first half of pregnancy. Unlike typical patients with GDM, patients with abnormal glucose tolerance in the first half of pregnancy may manifest severe degrees of hyperglycemia.

► How is laboratory screening accomplished?

Although the use of random glucose measurements or fasting glucose measurements have been advocated to screen for GDM, inadequate data are available to evaluate the relative effectiveness of these approaches. Random glucose screening does not appear to be adequately sensitive (40). The screening test most commonly used in the United States is the 50-g, 1-hour glucose challenge, using a pure glucose load of 50 g in 150 mL of fluid. Glucose polymer solutions, which provide a lower osmotic load for a given glucose load, appear to be associated with fewer gastrointestinal symptoms and have been demonstrated to yield fair correlation with monomeric glucose solutions (41–43). The use of jelly beans instead of a pure glucose challenge has been shown to be better tolerated, but this method has poor sensitivity (40%) when compared with glucose polymer solutions (80–90%) (44).

Among subjects with GDM, for whom the function of the screening test is most critical, either higher (45) or similar (46) values were reported when the test was administered in the fasting state. Therefore, given the lack of evidence that fasting improves the accuracy of the screening test and the fact that fasting may pose significant logistic problems, the 50-g, 1-hour screening test may be administered without regard to the time elapsed since the last meal.

► Should venous or capillary blood be used?

The original description of the screening test used venous whole blood (17), but laboratories have switched from whole blood to plasma or serum samples. Studies of the screening test have generally used venous plasma. Convenient and relatively inexpensive meters for measuring glucose in capillary blood samples raise the possibility of performing the screening test in an office setting without expensive and complicated laboratory equipment. During fasting, capillary and venous blood have similar glucose concentrations, but after a meal or glucose challenge, capillary glucose is higher than venous glucose. Laboratory instruments are generally checked for quality against standard samples at regular intervals to ensure accuracy. Precision is an important factor. Two studies of various meters used in pregnancy demonstrated inadequate precision for all but one or two meter systems tested (47, 48). Therefore, if capillary blood samples are to be used for GDM screening, the precision of the meter should be known, and its correlation with simultaneously obtained venous samples should be ascertained. Appropriate thresholds can then be derived. Office-based glucose testing is not recommended because of the difficulty in complying with required federal standards for testing. However, if used, it may be most practical to continue to use venous plasma samples and published thresholds for further testing.

► Is there an appropriate threshold value for the laboratory screening test?

The screening test threshold at which a diagnostic GTT is recommended will be arbitrary. The higher the threshold, the lower the sensitivity but the better the specificity and the lower the likelihood of a false-positive test result. The lower the threshold, the higher the sensitivity but the higher the likelihood of a false-positive test result and thus the performance of an unnecessary diagnostic GTT. O’Sullivan and Mahan (17) used venous whole blood samples and the Somogyi-Nelson method of glucose analysis. At the recommended threshold of 130 mg/dL, the screening test had a sensitivity of 79% and a specificity of 87%. When venous plasma and specific enzymatic methods of glucose analysis were used, 10% of women with GDM manifested screening test values between 130–139 mg/dL (18). Absolute sensitivity levels could not be determined because women with screening test values below 130 mg/dL did not undergo oral GTTs. When the threshold was lowered from 140 mg/dL to 130 mg/dL, the number of women requiring glucose tolerance testing increased from 14% to 23%, or approximately one quarter of patients.

Although a threshold of 140 mg/dL was recommended in the past, the most recent position statement of the American Diabetes Association ascribes a sensitivity of approximately 80% to this cutoff and 90% sensitivity with a threshold of 130 mg/dL and leaves the choice open (49). Because the precise cost-benefit ratio of diagnosing GDM remains unresolved, either threshold is acceptable.

► How is GDM diagnosed?

The diagnostic test specific for pregnancy and about which the greatest body of data exists is the 100-g, 3-hour oral GTT. Diagnostic criteria were originally derived by O’Sullivan and Mahan (50). Cutoff levels two standard deviations above the mean were found to be the best predictors for developing diabetes later in life.
There are no well-designed studies that demonstrate whether these diagnostic criteria are optimal to identify pregnancies at risk for maternal or perinatal morbidity. The relationship between maternal glucose intolerance and adverse pregnancy outcomes appears to be more or less continuous with no absolute threshold (4). Two sets of criteria were adapted from the original O’Sullivan and Mahan values when laboratories switched to venous plasma or serum. These samples yield results approximately 14% higher than does whole blood. The National Diabetes Data Group published conversions derived by adding 15% to each of the four thresholds (51). Lower thresholds were subsequently derived by also correcting for the change to enzymatic methods of glucose analysis (52). Expert panels have supported both criteria, but there are no data from clinical trials to determine which is superior (Table 1) (53).

A positive diagnosis requires that two or more thresholds be met or exceeded. The test is administered in the morning after an overnight fast. Patients should not smoke before the test and should remain seated during the test. Patients should be instructed to follow an unrestricted diet, consuming at least 150 g of carbohydrate per day for at least 3 days prior to the test. This should avoid carbohydrate depletion, which could cause spuriously high values on the GTT.

Patients with only one abnormal value have been demonstrated to manifest increased risk for macrosomic infants and other morbidities (54, 55). However, because the relationship between carbohydrate metabolism, macrosomia, and other morbidity is a continuum (4, 56), and because not all of this morbidity arises from carbohydrate intolerance, it should be anticipated that no threshold will identify all patients at risk.

▶ **How should blood glucose be monitored in a woman with GDM?**

The optimal frequency of blood glucose testing in patients with GDM has not been established. Whether daily testing is essential for women with GDM has not been proven. One large, prospective trial compared seven-times-daily self-glucose monitoring using memory-based reflectance meters with weekly fasting and 2-hour laboratory glucose determinations supplemented by four-times-daily self-monitoring with only test strips and no meters (57). The more intensively monitored group had fewer primary cesarean deliveries and fewer macroscopic neonates, and their infants were less likely to experience shoulder dystocia and neonatal hypoglycemia than the more conventionally monitored group. Other centers have reported similar results with four-times-daily glucose monitoring (25, 58). Although daily self-glucose monitoring has not been demonstrated to reduce perinatal mortality in women with GDM, it appears to be useful in reducing potentially adverse outcomes such as macrosomia. However, evidence from well-designed, randomized trials that compare daily self-glucose monitoring with less frequent assessment in women with GDM is still needed.

Further uncertainty surrounds the timing of glucose determinations and the selection of appropriate thresholds for intervention. In nonpregnant individuals, diabetes is most often managed using preprandial glucose determinations. However, the fetus may be more sensitive to glucose excesses than to the nadirs of glucose values at various times of the day. In studies of preexisting diabetes, 1-hour postprandial glucose values were found to be more predictive of fetal macrosomia than were fasting values (59), and a 1-hour value of 130 mg/dL or more was found to be an appropriate threshold (60). A randomized trial compared preprandial with 1-hour postprandial glucose measurements in 66 women whose GDM was severe enough to require insulin treatment by 30 weeks of gestation (25). Macrosomia, neonatal hypoglycemia, and cesarean deliveries for shoulder dystocia were significantly lower among those who had postprandial monitoring, and their glycohemoglobin levels also decreased more markedly than did the levels of the subjects who used preprandial monitoring. No studies are

### Table 1. Two Diagnostic Criteria for Gestational Diabetes Mellitus

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<td>mg/dL/mmol/L</td>
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<tr>
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Adapted from 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 2000;23(suppl 1):S4-S19
available to compare the efficacy of 1-hour postprandial versus the more traditional 2-hour postprandial glucose determinations.

Because these studies only included individuals with preexisting diabetes or those with GDM severe enough to require insulin treatment by 30 weeks of gestation, it remains to be established whether fasting or preprandial glucose measurements will suffice for individuals with milder forms of GDM. One study demonstrated a moderate correlation between fasting and 2-hour postprandial glucose values in GDM; if the fasting value was below 105 mg/dL, then only 17% of the 2-hour values exceeded 120 mg/dL (61). Given the available data, postprandial glucose values appear to be most effective at determining the likelihood of macrosomia and other adverse pregnancy outcomes in patients with GDM.

Is there a role for diet therapy in the treatment of GDM?

Although there are no available data comparing medical nutrition therapy (diet) with no treatment in women with GDM, there is one such randomized trial of women who had abnormal glucose challenge test results but normal oral GTT results (62). Those on the prescribed diet delivered fewer macrosomic infants. Nutritional intervention in women with GDM should be designed to achieve normal glucose levels and avoid ketosis, while maintaining appropriate nutrition and weight gain. The American Diabetes Association recommends nutritional counseling, if possible by a registered dietitian, with individualization of the nutrition plan based on height and weight (49). The American Diabetes Association also recommends an average of 30 kcal/kg/d based on prepregnant body weight for nonobese individuals (49). The most appropriate diet for women with GDM has yet to be established.

The American Diabetes Association suggests that obese women (body mass index >30) may do well with moderate caloric restriction (30–33%) (49). Caloric restriction of 30% in obese women with GDM was associated with pregnancy outcomes (birth weight and macrosomia) similar to those of a group of matched controls who had normal values on the glucose challenge screening tests (63). One concern about caloric restriction is that, although glucose levels may decrease, there is the possibility that it may cause starvation ketosis (64). Levels of glucose, free fatty acids, and ketone bodies have been assessed during each trimester in long-term follow-up studies of infants of women with and without diabetes. These studies have reported an inverse association between maternal circulating levels of ketone acids and IQ and ketone levels was weak (r = 0.2), it was statistically significant (P = 0.02); therefore, it would be prudent to avoid excessive ketonemia or ketonuria during pregnancy. When obese women with GDM were placed on moderate caloric restriction (25 kcal/kg of ideal non-pregnant weight per day), no ketonuria was detected during weekly clinic visits (67). Serum ketones were not reported. Available evidence does not support a recommendation for or against moderate caloric restriction in obese women with GDM. However, if caloric restriction is used, the diet should be restricted by no more than 33%, and ketonuria should be avoided.

Supplemental dietary fiber may improve glycemic control in women with type-2 diabetes. In a cohort study, increasing dietary fiber enrichment did not improve glucose control in women with GDM (68). Available evidence does not support the prescription of fiber supplements for GDM.

Is there a role for insulin in the treatment of GDM?

Some (69–71) but not all (72) prospective trials have demonstrated that insulin treatment of all women with GDM can reduce the likelihood of delivering a macrosomic baby. However, using such a paradigm would require that 100% of individuals be treated although less than half (between 9% and 40%) would benefit. It would be preferable to select the most appropriate patients for treatment.

One traditional approach has been to add insulin if medical nutrition therapy does not maintain fasting plasma glucose below 105 mg/dL or 2-hour values below 120 mg/dL or both. These thresholds have been extrapolated from recommendations for managing pregnancy in women with preexisting diabetes. A randomized trial demonstrated that using a 1-hour postmeal goal of 140 mg/dL, was effective in preventing adverse outcomes in women with GDM severe enough to require insulin (25). It would be logical, although unproven, that similar thresholds should be used for initiating insulin treatment. A study of individuals with preexisting diabetes found the most appropriate target 1-hour postprandial glucose level for preventing macrosomia was 130 mg/dL (60). It may be reasonable to apply these data to women with GDM. Women with higher fasting glucose levels are
more likely to require insulin therapy to achieve optimal glucose control than women with lower fasting glucose levels. Thirty-eight percent of women with GDM with an initial fasting plasma glucose level of 95 mg/dL or less required insulin to achieve “optimized control” (mean of seven daily values <100 mg/dL), whereas 70% required insulin when the initial fasting value was 95—104 mg/dL (73). Although each fasting glucose group delivered a similar, low proportion of babies with birth weights above the 90th percentile, large-for-gestational-age (LGA) babies were born to 29% of those treated with diet and 10% of those treated with insulin. All subjects with fasting values above 105 mg/dL were treated with insulin, and 14% had LGA offspring. These data suggest that insulin therapy should be considered for patients treated with medical nutrition therapy when 1-hour postprandial values exceed 130—140 mg/dL or 2-hour postprandial values exceed 120 mg/dL or fasting glucose exceeds 95 mg/dL.

Early third-trimester ultrasonography may help in identifying women with GDM who would benefit from insulin therapy despite relatively good metabolic control on diet. In a randomized trial of women with mild gestational diabetes, ultrasonound abdominal circumference greater than the 75th percentile at 29—33 weeks of gestation was effective in selecting patients among whom the LGA rate was reduced to 13% with insulin therapy compared with 45% in those randomized to diet alone (74).

A frequent question is how long to attempt dietary management before adding insulin. One study suggested diet be tried for 2 weeks before adding insulin if the initial fasting plasma glucose was 95 mg/dL or less (75). In women with GDM with initial fasting values above 95 mg/dL, the results of diet therapy alone were less satisfactory. The available evidence does not support a clear recommendation as to the number of times glucose values should exceed targets before insulin is added or the dosage increased.

No particular insulin regimen or insulin dose has been demonstrated to be superior for GDM. Generally, it is easiest for the patient to start with the simplest regimen and work up to a more complex regimen as needed. Regardless of the starting dosage, subsequent dosage adjustments should be based on the blood glucose levels at particular times of day. Because free insulin apparently does not cross the placenta, all types of insulin have been used in patients with GDM. Insulin lispro (Humalog), an analog of human insulin with a single amino acid substitution, has a more rapid onset of action than regular insulin and may be useful in improving postprandial glucose concentrations. It has been used in GDM and has been demonstrated not to cross the placenta (76).

Is there a role for exercise in the treatment of GDM?

Exercise often is recommended for individuals with diabetes, both as a way to achieve weight reduction and as a treatment to improve glucose metabolism. At least three randomized trials have explored exercise as an adjunct to, or substitute for, insulin in GDM. When women with GDM who needed intervention were randomly assigned to insulin or an exercise program, there was no difference in the likelihood of macrosomic infants, although glucose levels were not reported (77). A randomized trial of diet and exercise versus diet alone found improvement in both fasting plasma glucose and the response to a 50-g challenge in those who exercised (78) while a third study found improvement in cardiorespiratory fitness but no differences in glucose control with exercise (79). A regular exercise program has clear benefits for all women and may offer additional advantages for women with GDM. Women with GDM who lead an active lifestyle should be encouraged to continue a program of exercise approved for pregnancy.

Is there a role for oral antidiabetic agents in the treatment of GDM?

Oral antidiabetic agents have been contraindicated in pregnancy. The early-generation sulfonylureas crossed the placenta and had the potential to stimulate the fetal pancreas, leading to fetal hyperinsulinemia. There also was concern about the potential for teratogenicity, although diabetes itself is teratogenic, and it is difficult to distinguish the effects of the treatment from those of the disease. Glyburide, a second-generation sulfonylurea, was compared with insulin in a randomized trial among patients with GDM who failed to achieve adequate glycemic control with diet alone (80). Glucose control was similar, and the glyburide group had pregnancy outcomes similar to those of the insulin group, including rates of cesarean delivery, preeclampsia, macrosomia (>4 kg), and neonatal hypoglycemia. Cord serum analyses showed no detectable glyburide in the infants. At this time, no other oral agent has been shown to be safe and effective in GDM, and this study has not been confirmed. Further study is recommended before the use of newer oral hypoglycemic agents can be supported for use in pregnancy.

Is fetal assessment indicated in pregnancies complicated by GDM?

Antepartum fetal testing is recommended for patients with preexisting diabetes (81). If the increased risk of fetal demise in patients with preexisting diabetes is
related to suboptimal metabolic control, it would be expected that patients with GDM who have poor metabolic control also would be at risk and thus merit antepartum fetal surveillance. Patients with well-controlled GDM are presumably at lower risk for fetal death than are those whose condition is not well controlled or who require insulin therapy, but there is no consensus regarding antepartum testing in women with well-controlled GDM. There are no data available from randomized trials of antepartum testing in patients with GDM. Most case series report good outcomes with a given testing protocol and conclude the protocol used is appropriate. Twice-weekly nonstress tests and amniotic fluid volume determinations were associated with no stillbirths and a 4.9% rate of cesarean delivery for non-reassuring fetal status in a cohort of women with GDM who had fasting glucose levels below 105 mg/dL (82).

Another cohort study of women with GDM who required only diet therapy and were monitored by daily fetal movement determinations beginning at 28 weeks of gestation and who underwent nonstress testing beginning at 40 weeks of gestation found no stillbirths or neonatal deaths (83). Patients requiring insulin or who had previous stillbirths, chronic hypertension, or pregnancy-induced hypertension underwent earlier fetal testing as did patients with preexisting diabetes. Because this latter study lacked sufficient power to evaluate perinatal mortality, it is not possible to make an unequivocal recommendation. Despite the lack of conclusive data, it would seem reasonable that women whose GDM is not well controlled, who require insulin, or have other risk factors such as hypertension or adverse obstetric history should be managed the same as individuals with preexisting diabetes. The particular antepartum test selected, whether nonstress test, contraction stress test, or biophysical profile, may be chosen according to local practice.

Ultrasonography has been used to estimate fetal weight, especially to predict macrosomia prior to delivery. However, the reliability of these measures has not been established (84–86). Regression formulas using combined fetal measures for weight estimates are associated with systematic errors. Using existing formulas, an estimated fetal weight would have to exceed 4,800 g for the fetus to have more than a 50% chance of being macrosomic (87, 88). In addition, the use of ultrasound-derived measures of fetal weight have not been shown to be superior to clinical measures.

**When and how should delivery occur in pregnancies complicated by GDM?**

The timing of delivery in patients with GDM remains relatively open. When glucose control is good and no other complications supervene, there is no good evidence to support routine delivery before 40 weeks of gestation. In a study in which women with insulin-treated GDM and fetuses believed to be of appropriate weight for gestational age were randomized at 38 weeks of gestation to induction of labor within 1 week or expectant management, there was no difference in cesarean delivery rates (89). However, the induction group delivered a smaller proportion of LGA babies. In a cohort multiple time series study, a policy of induction of labor at 38–39 weeks of gestation for women with insulin-treated GDM was compared with the results in expectantly managed historic controls (90). There was no significant difference in macrosomia or cesarean delivery rates, but shoulder dystocia was experienced by 10% of the expectant management group beyond 40 weeks of gestation versus 1.4% in the group induced at 38–39 weeks of gestation. Although significant, these data have not been confirmed by additional studies.

Available data do not address women with GDM not treated with insulin or those believed to have macrosomic fetuses. Individuals whose metabolic control does not meet the goals described earlier, or is undocumented, or those with risk factors such as hypertensive disorders or previous stillbirth should be managed the same as those with preexisting diabetes.

When GDM is well controlled and dates are well documented, respiratory distress syndrome at or beyond 39 weeks of gestation is rare enough that routine amniocentesis for pulmonary maturity is not necessary (91). At earlier gestational ages, or when control is poor or undocumented, pulmonary maturity should be assessed before induction. However, when early delivery is planned because of maternal or fetal compromise, the urgency of the indication should be considered in the decision to perform amniocentesis.

Cesarean delivery rates are higher in women with GDM compared with controls, and the difference is not entirely attributable to fetal macrosomia (3, 9). It may be that caregivers are more prone to perform cesarean deliveries in patients with GDM because of concern about the likelihood of shoulder dystocia. There are no data to support a policy of cesarean delivery purely on the basis of GDM. However, macrosomia is distinctly more common in women with GDM, and shoulder dystocia is more likely at a given birth weight in pregnancies complicated by diabetes than in nondiabetic pregnancies (92, 93). It may be reasonable, therefore, to recommend cesarean delivery without a trial of labor at some particular threshold of fetal weight.

One of the problems in trying to apply such a threshold is the poor accuracy of ultrasound prediction of birth weight. In particular, a study reported that when
birth weight exceeds 4,500 g, only 50% of the fetuses weigh within 10% of the ultrasound-derived estimate (94). A decision analytic model was developed to estimate the potential effectiveness and costs of a policy of elective cesarean delivery for fetal macrosomia diagnosed by ultrasonography (95). Investigators factored in such considerations as the poor predictive accuracy of ultrasonography, the background cesarean delivery rates at various fetal weights, and the effect of maternal diabetes. The analysis predicted that in women with diabetes it would be necessary to perform 489 cesarean deliveries to prevent one permanent brachial plexus injury at a threshold of 4,000 g estimated fetal weight, or 443 cesarean deliveries at a threshold of 4,500 g estimated fetal weight. These figures are one fifth to one eighth of the figures developed for pregnancies of women without diabetes. The authors concluded such a policy may be tenable, although the merits are debatable. On the basis of available data, it is not possible to determine whether the potential benefits of cesarean delivery without labor at a given estimated fetal weight are similar for patients with GDM and those with preexisting diabetes. It would appear reasonable to recommend that patients with GDM be counseled regarding possible cesarean delivery without labor when the estimated fetal weight is 4,500 g or greater. When the estimated weight is 4,000–4,500 g, additional factors such as the patient’s past delivery history, clinical pelvimetry, and the progress of labor may be helpful to consider in determining mode of delivery.

With an estimated fetal weight greater than 4,500 g, prolonged second stage of labor or arrest of descent in the second stage is an indication for cesarean delivery. Because of the higher likelihood of shoulder dystocia at a given birth weight in the pregnancies of women with diabetes, it may be best to apply the above recommendation to an estimated fetal weight greater than 4,000 g for GDM. Operative deliveries from the midpelvis should be avoided, if possible, in patients with GDM who have an estimated fetal weight of 4,000 g or more and a prolonged second stage of labor (92, 96).

**Should women with a history of GDM be screened postpartum?**

Women with a history of GDM are at increased risk for developing diabetes (generally type-2 diabetes) later in life (97, 98). Diabetes will be diagnosed in some women soon after pregnancy, suggesting they had preexisting diabetes that was not diagnosed prior to pregnancy. Populations with a high prevalence of type-2 diabetes who do not have access to screening when not pregnant are at particularly high risk for this phenomenon (99). Current recommendations for the diagnosis and classification of diabetes in the nonpregnant state are based on the recommendations of an expert committee of the American Diabetes Association and are depicted in Table 2 (100). Diagnostic testing for diabetes may be performed after the immediate effects of pregnancy on glucose metabolism have dissipated and is most convenient at around the time of the postpartum checkup. However, there are no long-term follow-up studies that verify the benefit of postpartum diagnostic testing.

Although the American Diabetes Association advocates the use of a fasting plasma glucose determination as being less cumbersome than the oral GTT, the oral GTT will more accurately identify those women who had GDM and now have impaired glucose tolerance (101). Because the presence of such a condition may be important in counseling for future pregnancies, there may be advantages to performing the oral GTT as the initial diagnostic test after pregnancy complicated by GDM. If the results of both the fasting plasma glucose and the oral GTT are normal, subsequent follow-up tests may use the fasting plasma glucose.

**Table 2. Criteria for the Diagnosis of Diabetes Mellitus in the Nonpregnant State**

<table>
<thead>
<tr>
<th>Normal Values</th>
<th>Impaired Fasting Glucose or Impaired Glucose Tolerance</th>
<th>Diabetes Mellitus</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPG &lt;110 mg/dL</td>
<td>FPG 110–125 mg/dL</td>
<td>FPG ≥126 mg/dL</td>
</tr>
<tr>
<td>75-g, 2-h OGTT</td>
<td>75-g, 2-h OGTT</td>
<td>75-g, 2-h OGTT</td>
</tr>
<tr>
<td>2-h PG &lt;140 mg/dL</td>
<td>2-h PG 140–199 mg/dL</td>
<td>2-h PG ≥200 mg/dL</td>
</tr>
</tbody>
</table>

*Abbreviations: FPG, fasting plasma glucose; OGTT, oral glucose tolerance test; PG, plasma glucose. The diagnosis of diabetes mellitus should be confirmed on a separate day by any of these three tests.

The estimate of long-term risk for developing diabetes among women who had GDM depends on the diagnostic test used, the duration of follow-up, age, and other characteristics of the population studied; reported rates vary widely (102). In follow-up studies up to 28 years on the cohort of patients used to derive the O’Sullivan and Mahan criteria for GDM, diabetes was found in 50% of women who had GDM compared with 7% of controls (103). Factors identifiable during or shortly after pregnancy that increase the risk for subsequent diabetes include the degree of abnormality of the diagnostic GTT, the presence or absence of obesity, the gestational age at diagnosis of GDM, and the degree of abnormality of the postpartum oral GTT (104, 105). Individuals at increased risk should be counseled regarding diet, exercise, and weight reduction or maintenance to forestall or prevent the onset of type-2 diabetes.

Summary of Recommendations

The following recommendations are based primarily on consensus and expert opinion (Level C):

- Although universal glucose challenge screening for GDM is the most sensitive approach, there may be pregnant women at low risk who are less likely to benefit from testing. Such low-risk women should have all of the following characteristics:
  1. Age younger than 25 years
  2. Not a member of a racial or ethnic group with high prevalence of diabetes (eg, Hispanic, African, Native American, South or East Asian, or Pacific Islands ancestry)
  3. Body mass index of 25 or less
  4. No history of abnormal glucose tolerance
  5. No previous history of adverse pregnancy outcomes usually associated with GDM
  6. No known diabetes in first degree relative

- There is insufficient evidence to determine the optimal antepartum testing regimen for women with GDM with relatively normal glucose levels on diet therapy and no other risk factors.

- Either the plasma or serum glucose level established by Carpenter and Coustan or the plasma level designated by the National Diabetes Data Group conversions are appropriate to use in the diagnosis of GDM.

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dependent of maternal obesity and advanced age in Korean women with GDM. Diabetes Care 1997;20:1582–1588 (Level II-2)


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86. Sandmire HF. Whither ultrasonic prediction of fetal macrosomia? Obstet Gynecol 1993;82:860–862 (Level III)
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The MEDLINE database, the Cochrane Library, and ACOG’s own internal resources and documents were used to conduct a literature search to locate relevant articles published between January 1985 and June 2000. The search was restricted to articles published in the English language. Priority was given to articles reporting results of original research, although review articles and commentaries also were consulted. Abstracts of research presented at symposia and scientific conferences were not considered adequate for inclusion in this document. Guidelines published by organizations or institutions such as the National Institutes of Health and the American College of Obstetricians and Gynecologists were reviewed, and additional studies were located by reviewing bibliographies of identified articles. When reliable research was not available, expert opinions from obstetrician–gynecologists were used.

Studies were reviewed and evaluated for quality according to the method outlined by the U.S. Preventive Services Task Force:

I Evidence obtained from at least one properly designed randomized controlled trial.
II-1 Evidence obtained from well-designed controlled trials without randomization.
II-2 Evidence obtained from well-designed cohort or case–control analytic studies, preferably from more than one center or research group.
II-3 Evidence obtained from multiple time series with or without the intervention. Dramatic results in uncontrolled experiments could also be regarded as this type of evidence.
III Opinions of respected authorities, based on clinical experience, descriptive studies, or reports of expert committees.

Based on the highest level of evidence found in the data, recommendations are provided and graded according to the following categories:
Level A—Recommendations are based on good and consistent scientific evidence.
Level B—Recommendations are based on limited or inconsistent scientific evidence.
Level C—Recommendations are based primarily on consensus and expert opinion.