Management of Diabetes in Pregnancy
Aaron B. Caughey, MD, MPP, MPH

ABSTRACT

PURPOSE: To review preconceptional counseling and management of pregnancy in patients with pregestational and gestational diabetes.

EPIDEMIOLOGY: In the United States, approximately 4% to 6% of all pregnant women have diabetes. Among them, 12% have type 1 or type 2 diabetes; 88% experience gestational diabetes.

REVIEW SUMMARY: Although historically diabetes during pregnancy heralded poor outcomes for mother and infant, today most patients can enjoy normal outcomes when adequate glycemic control is achieved. However, management of these patients is clinically challenging and must be individualized. This article reviews the management of type 1, type 2, and gestational diabetes, including preconceptional counseling and postpartum care.

TYPE OF AVAILABLE EVIDENCE: Nationally recognized consensus guidelines, patient surveys, randomized-controlled trials, expert opinion.

GRADE OF AVAILABLE EVIDENCE: Poor to good.

CONCLUSION: Women with diabetes who are aggressively managed and treated can enjoy normal, healthy pregnancies. Frequent blood glucose monitoring and physician contact allow for individualized care to achieve optimal outcomes. Evolving technologies promise to provide more therapeutic options.


In the United States approximately 4% of all pregnant women have diabetes mellitus (DM). Among them, 88% experience gestational diabetes mellitus (GDM), but 12% have either type 1 or type 2 DM.1 Historically, pregnancy in women with preexisting diabetes was fated to miscarriage, perinatal mortality, and congenital anomalies. By the 1940s, despite the widespread use of insulin therapy, diabetes in pregnancy was still rare and was associated with not only fetal complications, but also diabetic ketoacidosis and preeclampsia. In particular, the severity of disease was associated with negative outcomes.2 Fortunately, with the evolution of insulin and the oral agents, the development of blood glucose meters, and an expanded knowledge of management of women with diabetes during pregnancy, most women experience a successful gestation and delivery. Challenges do remain in caring for pregnant patients with diabetes, particularly those with poor glycemic control. Thus, effective management of both the pregnancy and the diabetes is essential. This article reviews current recommendations for care of the woman with pregestational or gestational diabetes.

Even in women without diabetes, pregnancy induces increased insulin resistance and reduced sensitivity to insulin action resulting from hormones produced by the placenta, in particular human placental lactogen and human chorionic somatomammotropin.3 In women with marginal insulin secretory capacity and/or already impaired insulin resistance, a hyperglycemic syndrome resembling type 2 diabetes ensues: gesta-
tional diabetes. Of note, because the levels of the diabete
genic placental hormones increase with placental size, gestational diabetes usually is not present until well into the second or third trimester of pregnancy.

This naturally occurring insulin resistance also complicates pregestational diabetes. Because of increasing insulin resistance, women who had diabetes before becoming pregnant will experience growing insulin requirements during pregnancy. These women will almost always need to be switched to subcutaneous insulin. Type 1 diabetes, on the other hand, is characterized by impairments in insulin production resulting from destruction of the β cells of the pancreas, and always requires insulin treatment. For both types of women with diabetes, because the increasing insulin resistance is related to ongoing increases in placental function occurring throughout pregnancy, changes to insulin regimens may need to occur weekly during pregnancy.

Diabetes in pregnancy is particularly important because it is associated with complications in the fetus and neonate. Glucose readily crosses the placenta, leading to fetal hyperglycemia. This hyperglycemia induces the fetal pancreas to secrete higher levels of insulin, thus causing an overgrowth syndrome of both increased birth weight as well as increased fat distribution in the fetal trunk. These anatomic changes lead to a lower likelihood of achieving a vaginal birth, and when vaginal birth is achieved, the risk of shoulder dystocia is higher. Because of the increased insulin levels at birth, the neonate is then at risk of developing hypoglycemia. Thus, diabetes in pregnancy clearly is an issue for both mother and child.

### PREGESTATIONAL DIABETES

For patients with type 1 or type 2 diabetes, normalizing blood glucose concentrations is essential, and this should be achieved prior to conception if possible. An elevated HbA1c during the first trimester of pregnancy increases risks for spontaneous abortion and congenital anomalies.

In particular, patients with pregestational diabetes are at increased risk for cardiac anomalies, neural tube defects, and skeletal malformations (Table 1). In women whose HbA1c values are >8%, these risks are 3- to 6-fold greater than the risk of women with lower values.

Certain obstetric and neonatal risks also are associated with uncontrolled glucose during pregnancy. Fetal macrosomia, or birth weight more than 4000 or 4500 g, is more common as a result of poor glycemic control. This can lead to higher rates of cesarean delivery and shoulder dystocia. In addition, there is a greater risk for intrauterine fetal demise, which, though worse in the setting of poor glycemic control and/or women with other complications of diabetes, appears elevated over the baseline population in all patients with pregestational diabetes. Other risks include higher rates of respiratory distress syndrome, neonatal jaundice, hypoglycemia, admission to the neonatal intensive care unit, and preeclampsia. Because of the risk of preeclampsia or neonatal compromise, indicated preterm delivery is more common, as well. If hypertension and nephropathy accompany poor glycemic control, the fetus is at increased risk for growth restriction and low birth weight. Long-term outcomes for the children of patients with diabetes related to hyperglycemia and hyperinsulinemia during gestation include obesity, carbohydrate intolerance, and insulin resistance.

A full evaluation should take place and individualized plans should be established for each woman based on her prior history and current diabetes regimen and control (see sidebar). Often, multidisciplinary care is employed, including consultations by a nurse/clinical diabetes educator (CDE), dietician, endocrinologist, ophthalmologist, and obstetrician.

### PRECONCEPTIONAL COUNSELING

Fetal and neonatal risks can be substantially reduced with the achievement of adequate glucose control during pregnancy. In addition, some experts recommend that in order to reduce the risk of fetal abnormalities, particularly neural tube defects, mothers with diabetes should take a high daily dosage of folic acid (4 mg), to be taken as folic acid alone as opposed to a multivitamin, prior to gestation and throughout the first trimester.

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**Table 1. Fetal Anomalies Associated With Pregestational Diabetes Mellitus**

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<tr>
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MANAGEMENT IN PREGNANCY

The therapeutic goal for glucose control is to bring HbA1C as close to the normal range as possible.39 Fasting plasma glucose levels should be maintained at 70 mg/dL to 95 mg/dL before meals and <140 mg/dL at 1 hour postprandial, or <120 mg/dL at 2 hours postprandial.18 However, the progressive insulin resistance that occurs during pregnancy leads to increased insulin requirements that in some cases may be more than double the preconception dose.44 It is common for many patients with type 1 diabetes to be using glargine insulin as their basal insulin. However, despite its attractive serum profile (it lacks a peak), the safety data on glargine in pregnancy are limited to case reports.38–39 Thus, the theoretical risks of this insulin versus the possible benefits of improved control as compared with the use of NPH insulin need to be weighed when counseling such women. For some patients with type 1 diabetes, increased insulin requirements may be accommodated with the use of an insulin pump. Usually, 50% to 60% of the total daily insulin dose is administered as a continuous basal rate, with boluses before meals and snacks.45 Patients must be carefully evaluated for their ability to use this device, as it requires a degree of sophistication as well as consistent compliance. Although the advantages of the pump include a more flexible lifestyle, a decrease in episodes of severe hypoglycemia, and better control of hyperglycemia from the “dawn” phenomenon,46 costs may be a deterrent. For type 2 diabetes, oral hypoglycemic agents usually are changed to insulin in order to achieve glycemic targets. If injectable insulin cannot achieve reasonable glycemic control, such women also occasionally are converted to an insulin pump. The patient must become adept at self-monitoring techniques and be educated regarding the importance of diet, exercise, and frequent blood glucose monitoring. Carbohydrate counting should be the primary method of evaluating the diet for patients with diabetes, and is particularly useful during pregnancy. The traditional American Diabetes Association (ADA) diet was calculated using kilocalories (kcals). For women with a nor-
If NPO, start D5W, 100 cc/hr 181–220
Start insulin drip 0.5 u/hr 80–140

Maintain BS Action (u/hr)

Type 1 DM

<table>
<thead>
<tr>
<th>BS</th>
<th>Action (u/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;80</td>
<td>↓ 0.5 u/hr</td>
</tr>
<tr>
<td>80–140</td>
<td>Maintain</td>
</tr>
</tbody>
</table>

(or same as last pump dose)

140–180 | ↑0.5 u/hr |
181–220 | ↑1.0 + 1-u bolus |
>220   | ↑1.0 + 2-u bolus |

*This regimen will work for a majority of patients, but may need to be individualized.
DM = diabetes mellitus; BS = blood sugar; q = every; u = unit(s); NPO = nothing by mouth.

Table 3. Pregestational Type 2 Diabetes: Labor and Delivery—Insulin Drip

<table>
<thead>
<tr>
<th>BS</th>
<th>Action (u/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;90</td>
<td>No insulin</td>
</tr>
<tr>
<td>80–100</td>
<td>0.5 u/hr</td>
</tr>
<tr>
<td>100–140</td>
<td>1.0 u/hr</td>
</tr>
<tr>
<td>141–180</td>
<td>1.5 u/hr</td>
</tr>
<tr>
<td>181–220</td>
<td>2.0 + 2-u bolus</td>
</tr>
<tr>
<td>&gt;220</td>
<td>2.5 + 4-u bolus</td>
</tr>
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*This regimen will work for a majority of patients, but may need to be individualized.
DM = diabetes mellitus; BS = blood sugar; q = every; u = unit(s).

Labor and Delivery

Insulin requirements usually decrease during labor as the patient may be fasting and exerting significant energy. An insulin infusion during labor and delivery is commonly used to maintain tight regulation of plasma glucose. Sample regimens for type 1 and type 2 diabetes are shown in Tables 2 and 3. When labor is induced in the morning, patients with type 2 diabetes usually have taken their NPH insulin the night before. If labor is induced with prostaglandins, they may take their usual NPH insulin dose in the morning. If labor is induced with oxytocin, they should skip the morn-
ing NPH dose. The reason for this is that when in active labor, having long-acting insulin on board can lead to hypoglycemia, which can be much harder to correct than hyperglycemia. Thus, if uncertain, it usually is better to hold long-acting insulin in favor of using an insulin drip. In the setting of a scheduled cesarean delivery, patients may take their usual dose of NPH insulin the prior evening, but nothing by mouth and no insulin after midnight.

Patients with type 1 diabetes always require exogenous insulin, and thus are managed differently when labor is induced. Those using continuous infusion can remain on their pumps until the active phase of labor, when they are switched to an insulin drip protocol. Those women who are taking NPH insulin whose labor is induced with prostaglandins typically take their usual NPH insulin in the morning. Patients induced with oxytocin should take half of the NPH dose in the morning. Those undergoing scheduled cesarean delivery should take the usual NPH dose in the evening, with nothing by mouth after midnight, except in the case of hypoglycemia. In the morning, they then take half of their normal NPH insulin dose. Because of the concern for both hypo- and hyperglycemia, it is best to schedule cesarean deliveries in patients with type 1 diabetes for first thing in the morning.

**Postpartum Care**

The postpartum weeks are characterized by a dramatic decrease in the need for insulin as the insulin resistance of pregnancy resolves following delivery. Though patients with type 2 diabetes may not require any insulin during this period, patients with type 1 diabetes should always receive some insulin as a result of a lack of endogenous insulin. A protocol for postpartum management that is used at this author’s facility is shown in Table 4.

Breast-feeding can affect efforts to control serum glucose and there may be a tendency for hypoglycemia. In particular, because of the caloric requirements associated with breast-feeding, women’s overall insulin demands are decreased. In turn, they are at higher risk for hypoglycemia. Close monitoring of patients should continue during the lactation period.

**Gestational Diabetes Mellitus**

Gestational diabetes mellitus (GDM) is defined as glucose intolerance with onset or first detection during pregnancy. Approximately 5% to 7% of all pregnancies are complicated by GDM, accounting for more than 200,000 pregnancies annually. Major risk factors for developing GDM include increasing maternal age, family history of diabetes, history of GDM in a prior pregnancy, and increased pregravid body mass index (BMI). GDM is more common among Asian, Hispanic/Latina, and Native American women. Although early studies demonstrated an increased risk among African American women, these differences appear to dissipate when controlling for confounders such as obesity.

GDM has been linked to increased maternal perinatal morbidity (resulting from an increase in cesarean deliveries and forceps or vacuum extraction, as well as third- and fourth-degree perineal lacerations), principally through its association with fetal macrosomia caused by hyperglycemia during the latter half of the pregnancy. Macrosomia also is associated with an increased risk for adverse neonatal outcomes, such as shoulder dystocia, brachial plexus injuries, and clavicular fracture. Additionally, because of different biometrics, infants of diabetic pregnancies with the same birth weight as those from nondiabetic pregnancies are at increased risk for shoulder dystocia. These infants appear to carry the same risk as an infant from a non-diabetic pregnancy who weighs 250 g more.

In addition to the effects from macrosomia, women with gestational diabetes have a higher rate of developing preeclampsia. In pregnancies truly complicated by GDM as opposed to gestational diabetes, neonates should not have a higher risk of congenital anomalies. However, because of the metabolic effects of hyperglycemia in the third trimester, they do carry increased risk of neonatal hypoglycemia, respiratory distress syndrome, jaundice, and hypocalcemia.

**Diagnosis of Gestational Diabetes Mellitus**

Gestational diabetes was first screened for by O’Sullivan and Mahan in 1973 using an oral glucose load. Currently, 94% of providers in the United States screen all pregnant patients. Although the US Preventive Services Task Force indicates that better quality evidence is needed to support universal screening, a 2001 Practice Bulletin from the American

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**Table 4. Pregestational Diabetes: Postpartum**

- Anticipate rapid drop in insulin resistance
- Type 1 diabetes mellitus
  - Continue on drip until 12 to 24 hours postpartum
  - Then utilize approximately 80% prepregnancy dose of NPH / Lantus / pump
  - Use prepregnancy carbohydrate ratios
- Type 2 diabetes mellitus
  - Either 80% of prepregnancy or
  - Half of term dosing regimen
College of Obstetricians and Gynecologists (ACOG) notes that because only a small percentage of patients meet criteria for low risk, universal 50-g, 1-h glucose loading test (GLT) screening may be a more practical approach.\(^4\) Again, risk factors for GDM include a family history of type 2 diabetes in first-degree relatives, prior macrosomic fetus, nonwhite ethnicity, obesity (BMI >25 kg/m²), increasing maternal age (>25 years), a history of abnormal glucose tolerance, and prior GDM.\(^4\) A 1999 study demonstrated that if only pregnant patients meeting these ADA criteria were screened, 97% of GDM would be diagnosed. However, only 10% of patients would go unscreened.\(^5\)

Establishing a threshold for defining GDM has been a matter of some controversy. Coustan et al demonstrated that using the a 50-g, 1-hour GLT with a threshold of 140 mg/dL, only 80% of GDM would be diagnosed, with a 13% screen positive rate.\(^6\) However, if a threshold of 135 mg/dL is used, 98% of GDM is diagnosed, but up to 1 in 5 patients will be subjected to the 3-hour test.\(^6\) Near 100% sensitivity can be achieved utilizing a screen of 130 mg/dL, but this would be with 22% of individuals having a positive screening test.

Another area of controversy is whether the same screening test should be used for all patients. Our recent study of screening findings by ethnic group found different testing characteristics among different ethnicities (Table 5).\(^6\) The question is how to use these data? For example, if the goal is to achieve a 95% sensitivity, 135 mg/dL could be used among African American women, but 132 or 133 mg/dL would be used for women of other ethnicities. If the goal is to keep false positives to <10%, 140 mg/dL would be an adequate threshold for white women, and 135 mg/dL for African American women, but the threshold would need to be higher for women of Latina or Asian descent.\(^6\)

Women with a prior history of GDM should undergo screening and diagnosis as soon as they present for subsequent prenatal care, using the criteria shown in Table 6. In this population, it is reasonable to omit the GLT and to perform a 3-hour oral glucose tolerance test (OGTT) instead.\(^7\) For all screened patients, the diagnosis of GDM is based on an OGTT. Most clinicians use the Carpenter-Coustan diagnostic criteria to make a diagnosis of GDM.

### MANAGEMENT OF GESTATIONAL DIABETES MELLITUS

The initial management of women with GDM includes education, diet, light exercise, and assessment of plasma glucose with self-monitored blood glucose measurements. The glucose levels should be assessed 4 times daily (fasting and postprandial) with the goal of maintaining glycemic levels <95 mg/dL when fasting and <140 mg/dL 1 hour postprandial.\(^8\) Of note, some clinicians utilize 2-hour postprandial evaluations with a goal of <120 mg/dL.\(^9,10\) Carbohydrate counting is an important component of management, and should be utilized to obtain a daily carbohydrate distribution of 30 to 45 g at breakfast, 45 to 60 g at lunch and dinner, and 15 to 30 g for mid-morning, afternoon, and evening snacks. Light exercise after each meal, as simple as a 15-minute walk, can help reduce postprandial values to the normal range. Utilizing a combination of these management schemes has been demonstrated to reduce maternal and neonatal morbidity, even in patients with GDM and mild insulin resistance.\(^11\) In addition, at this author’s institution we commonly obtain an ultrasound at 36 weeks’ gestation for an estimated fetal weight. Depending on these findings in women who have not required medical intervention with insulin or oral agents, commonly such pregnan-

### Table 5. Gestational Diabetes: Screening\(^6\)

<table>
<thead>
<tr>
<th>GLT (mg/dL)</th>
<th>Sensitivity (Specificity)</th>
<th>Sens. (Spec.)</th>
<th>Sens. (Spec.)</th>
<th>Sens. (Spec.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caucasian</td>
<td>99.5% (92.5%)</td>
<td>93.9% (87.1%)</td>
<td>89.2% (90.7%)</td>
<td>75.6% (92.9%)</td>
</tr>
<tr>
<td>African American</td>
<td>98.9% (88.4%)</td>
<td>96.5% (91.1%)</td>
<td>92.9% (93.8%)</td>
<td>81.2% (96.0%)</td>
</tr>
<tr>
<td>Latina</td>
<td>98.3% (80.9%)</td>
<td>94.1% (85.5%)</td>
<td>89.9% (88.7%)</td>
<td>78.2% (91.1%)</td>
</tr>
<tr>
<td>Asian</td>
<td>98.5% (75.9%)</td>
<td>93.0% (81.1%)</td>
<td>88.8% (86.0%)</td>
<td>79.8% (89.0%)</td>
</tr>
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GLT = glucose loading test.

### Table 6. Diagnosis of Gestational Diabetes With a 100-g Oral Glucose Load

<table>
<thead>
<tr>
<th>Glucose level (mg/dL)</th>
<th>Fasting</th>
<th>1 hour</th>
<th>2 hours</th>
<th>3 hours</th>
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<tbody>
<tr>
<td></td>
<td>95</td>
<td>180</td>
<td>155</td>
<td>140</td>
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Two or more of the venous plasma concentrations must be met or exceeded for a positive diagnosis. The test should be done in the morning after an overnight fast of at least 8 and 14 hours and after at least 3 days of unrestricted diet (≥150 g carbohydrate/day) and unlimited physical activity. The subject should remain seated and should not smoke throughout the test.
cies are managed expectantly until the due date. With a finding of impending macrosomia, some clinicians will offer induction of labor. Though such an intervention has not been shown to change the risk of cesarean delivery, induction has been associated with lower birth weights.

If diet and exercise fail to maintain self-monitored glycemia at <95 mg/dL (fasting plasma glucose) and <140 mg/dL (1 hour postprandial), the standard of care is to initiate subcutaneous insulin therapy. Free insulin does not cross the placenta, therefore no particular risks need to be considered other than accidental insulin overdose leading to hypoglycemia. In fact, patients can be counseled that the glucose does cross the placenta leading to metabolic problems in the fetus and neonate, which is precisely what is being prevented by insulin therapy. However, there are no particular data comparing the efficacy of the multitude of feasible insulin regimens. Most commonly, we utilize NPH insulin at bedtime to control elevated fasting blood glucose values and fasting acting insulin lispro (Humalog) to control breakfast and dinner hyperglycemia. For lunchtime hyperglycemia, either a pre-lunch insulin lispro dose can be used or a dose of NPH insulin given at the same time as the prebreakfast insulin lispro dose. The former carries no risk of mid-morning hypoglycemia, but requires a midday injection. Regular insulin, which has a 30-minute onset and an approximately 2-hour peak, should not be used in the management of DM—particularly not in GDM, as it is quite onerous to schedule injections precisely before mealtimes. Glargine insulin, as mentioned earlier, has an attractive serum profile, but has little safety data in pregnancy with women with GDM which is based on 1 case report of 4 patients.

Because many patients with GDM will have problems primarily with postprandial hyperglycemia, glargine insulin likely only has a small role at best in future management of GDM.

**USE OF ORAL HYPOGLYCEMIC AGENTS**

Recent investigations have assessed the use of oral hypoglycemic agents in GDM. A randomized trial by Langer compared glyburide with conventional insulin therapy in 404 patients with GDM and found that there was "no difference" in neonatal outcomes.

However, the study was underpowered to demonstrate a difference between these 2 groups, and actually demonstrated a trend towards an increase in neonatal complications in the glyburide-treated group. Unfortunately, a number of providers immediately began utilizing glyburide in patients without awaiting further evidence. Since the initial study, several subsequent retrospective studies have further investigated use of glyburide in GDM. The most recent and largest was a study of 584 women reported by Jacobson et al. The study compared women initially managed with insulin versus glyburide. Whereas the study demonstrated no difference in neonatal birth weight, it did report higher rates of preeclampsia and higher rates of phototherapy use in the neonates delivered in the glyburide group. Another recent study found higher rates of macrosomia and neonatal hypoglycemia in the neonates whose mothers were treated with glyburide.

Further, it appears that approximately 20% of women treated with glyburide will fail this management, resulting in less time to optimally achieve control with insulin. Finally, ACOG has designated use of glyburide in pregnancy to be experimental. Therefore, glyburide should not be routinely used in GDM. Additionally, experts recommend that metformin be avoided during pregnancy as it does cross the placenta and its use in pregnancy has not been well studied.

Again, the use of oral hypoglycemic agents in pregnancy should be considered experimental and reserved for research protocols.

The protocol at this author's institution calls for management of patients with GDM on insulin similar to that of patients with type 2 diabetes. We initiate antenatal testing at 32 weeks and induce labor at 38 to 39 weeks of gestation. Again, this is based upon the ability to maintain adequate glycemic control and the estimated fetal weight on ultrasound obtained at 36 weeks of gestation. Additionally, there is only 1 prospective randomized trial in such women that demonstrated no difference in the rate of cesarean delivery, but less macrosomia in women induced at 38 to 39 weeks of gestation.

In labor, blood glucose values via self-monitored blood glucose measurements are checked every 2 hours and if the values rise above 120 mg/dL, an insulin drip is initiated and blood glucose monitored hourly.

**POSTPARTUM MANAGEMENT**

Women who experience GDM, particularly those who are overweight, have a 50% lifetime risk for developing type 2 diabetes. Risk factors include obesity, gestational age at diagnosis of GDM, and the degree of abnormality of postpartum glucose tests. Patients determined to be at risk should be counseled regarding diet, exercise, and weight reduction to delay or prevent the onset of type 2 diabetes.

Because of the high risk of type 2 diabetes in patients with GDM, diagnostic testing for diabetes is appropriate at the time of the 6-week postpartum visit. It is unclear whether the traditional 75-g 2-hour OGTT or simply a fasting serum glucose may be more useful at this time. Whereas the oral glucose challenge test may identify more patients with abnormal carbohydrate tolerance, it is uncertain that such a test has added benefit. Because the ADA is currently using fasting glucose >125 mg/dL to
define type 2 diabetes, and values between 100 mg/dL and 125 mg/dL to indicate a “prediabetic” condition, this is the test we recommend. Of note, ACOG indicates that there may be advantages to performing the OGTT as the initial diagnostic test after pregnancy complicated by GDM.44 Again, it is not entirely clear what these advantages are other than reinforcing the idea that these women are at increased risk for eventually developing type 2 diabetes. The protocol at this author’s institution calls for fasting blood glucose testing at 6 weeks, 6 months postpartum, and annually thereafter.

**Elective Cesarean Delivery**

There is much debate over whether elective cesarean delivery should be employed in patients with pregestational or gestational diabetes for the prevention of birth trauma, specifically shoulder dystocia and brachial plexus injury. The most recent ACOG bulletin on the topic of macrosomia suggests that in patients without diabetes, an elective cesarean is reasonable with an estimated fetal weight at 5000 g or above.76-77 However, they are less clear about what to do in the setting of macrosomia and diabetes. If one were to utilize the information that a patient with diabetes has an equal risk of shoulder dystocia as does a nondiabetic patient with a fetus whose birth weight is 250 g higher, it seems reasonable to offer an elective cesarean with an estimated fetal weight of 4750 g or higher. Of note, it has been estimated that with a threshold of 4500 g in patients with diabetes, 443 cesareans would need to be performed to prevent 1 brachial plexus injury.78 Whether this trade-off is worth the increased risks of cesarean delivery is unclear.

**Areas for Future Research**

In the future, hopefully larger randomized-controlled studies will examine the efficacy of glyburide and other oral hypoglycemic agents such as metformin in the care of pregnant women with diabetes. Such studies will need to avoid the prior problems of lack of statistical power and Type II error. Though it is common that most institutions utilize universal screening, future research also is necessary to examine whether there are low-risk populations that may not require screening. Further, such risk examination also should determine which groups of women (stratified by age, race/ethnicity, BMI, and family history) will benefit from diabetes screening early in pregnancy. Prospective cohort studies designed to follow both women and neonates after diabetic pregnancies also may help to characterize the long-term medical issues in this population of mothers and their children.

Regarding technologic advances, studies of inhaled insulin have been conducted and may become a marketed reality in the very near future.79 Continuous glucose monitoring systems are currently used by some patients with type 1 diabetes, and it remains to be seen whether their use will improve glycemic control. Meters capable of beaming information to pumps and regulating insulin injections are being developed. On the surgical front, pancreatic transplantation continues to be investigated.80 However, short-term survival is reported to be better with use of exogenous insulin.81

**Conclusion**

Although diabetes during pregnancy at one time heralded dire outcomes for the mother and fetus, today, many such women enjoy happy and healthy pregnancies. The evolution of technologies and clinical knowledge has made it possible for these patients to experience pregnancies similar to those of the nondiabetic population, but patient management can still be clinically challenging. Further advances in the near future will offer physicians and patients more options for achieving optimal outcomes.

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