



American Diabetes Association

# 14. Management of Diabetes in Pregnancy: *Standards of Medical Care in Diabetes—2019*

*Diabetes Care* 2019;42(Suppl. 1):S165–S172 | <https://doi.org/10.2337/dc19-S014>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at [professional.diabetes.org/SOC](http://professional.diabetes.org/SOC).

## DIABETES IN PREGNANCY

The prevalence of diabetes in pregnancy has been increasing in the U.S. The majority is gestational diabetes mellitus (GDM) with the remainder primarily preexisting type 1 diabetes and type 2 diabetes. The rise in GDM and type 2 diabetes in parallel with obesity both in the U.S. and worldwide is of particular concern. Both type 1 diabetes and type 2 diabetes in pregnancy confer significantly greater maternal and fetal risk than GDM, with some differences according to type of diabetes. In general, specific risks of uncontrolled diabetes in pregnancy include spontaneous abortion, fetal anomalies, preeclampsia, fetal demise, macrosomia, neonatal hypoglycemia, and neonatal hyperbilirubinemia, among others. In addition, diabetes in pregnancy may increase the risk of obesity and type 2 diabetes in offspring later in life (1,2).

## PRECONCEPTION COUNSELING

### Recommendations

- 14.1** Starting at puberty and continuing in all women with reproductive potential, preconception counseling should be incorporated into routine diabetes care. **A**
- 14.2** Family planning should be discussed and effective contraception should be prescribed and used until a woman is prepared and ready to become pregnant. **A**
- 14.3** Preconception counseling should address the importance of glycemic management as close to normal as is safely possible, ideally A1C <6.5% (48 mmol/mol), to reduce the risk of congenital anomalies, preeclampsia, macrosomia, and other complications. **B**

All women of childbearing age with diabetes should be counseled about the importance of tight glycemic control prior to conception. Observational studies show an increased risk of diabetic embryopathy, especially anencephaly, microcephaly, congenital heart disease, and caudal regression, directly proportional to elevations in

*Suggested citation: American Diabetes Association. 14. Management of diabetes in pregnancy: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1):S165–S172*

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

A1C during the first 10 weeks of pregnancy (3). Although observational studies are confounded by the association between elevated periconceptional A1C and other poor self-care behaviors, the quantity and consistency of data are convincing and support the recommendation to optimize glycemic control prior to conception, with A1C <6.5% (48 mmol/mol) associated with the lowest risk of congenital anomalies (3–6).

There are opportunities to educate all women and adolescents of reproductive age with diabetes about the risks of unplanned pregnancies and improved maternal and fetal outcomes with pregnancy planning (7). Effective preconception counseling could avert substantial health and associated cost burdens in offspring (8). Family planning should be discussed, and effective contraception should be prescribed and used until a woman is prepared and ready to become pregnant.

To minimize the occurrence of complications, beginning at the onset of puberty or at diagnosis, all girls and women with diabetes of childbearing potential should receive education about 1) the risks of malformations associated with unplanned pregnancies and poor metabolic control and 2) the use of effective contraception at all times when preventing a pregnancy. Preconception counseling using developmentally appropriate educational tools enables adolescent girls to make well-informed decisions (7). Preconception counseling resources tailored for adolescents are available at no cost through the American Diabetes Association (ADA) (9).

### Preconception Care

#### Recommendations

**14.4** Women with preexisting type 1 or type 2 diabetes who are planning pregnancy or who have become pregnant should be counseled on the risk of development and/or progression of diabetic retinopathy. Dilated eye examinations should occur ideally before pregnancy or in the first trimester, and then patients should be monitored every trimester and for 1-year postpartum as indicated by the degree of retinopathy and as recommended by the eye care provider. **B**

**14.5** Women with preexisting diabetes should ideally be managed in a multidisciplinary clinic including an endocrinologist, maternal-fetal medicine specialist, dietitian, and diabetes educator, when available. **B**

Preconception visits should include rubella, syphilis, hepatitis B virus, and HIV testing, as well as Pap test, cervical cultures, blood typing, prescription of prenatal vitamins (with at least 400 mg of folic acid), and smoking cessation counseling if indicated. Diabetes-specific testing should include A1C, thyroid-stimulating hormone, creatinine, and urinary albumin-to-creatinine ratio; review of the medication list for potentially teratogenic drugs, i.e., ACE inhibitors (10), angiotensin receptor blockers (10), and statins (11,12); and referral for a comprehensive eye exam. Women with preexisting diabetic retinopathy will need close monitoring during pregnancy to ensure that retinopathy does not progress (13). Preconception counseling should include an explanation of the risks to mother and fetus related to pregnancy and the ways to reduce risk and include glycemic goal setting, lifestyle management, and medical nutrition therapy.

Several studies have shown improved diabetes and pregnancy outcomes when care has been delivered from preconception through pregnancy by a multidisciplinary group focused on improved glycemic control (14–16). One study showed that care of preexisting diabetes in clinics that included diabetes and obstetric specialists improved care (17). However, there is no consensus on the structure of multidisciplinary team care for diabetes and pregnancy, and there is a lack of evidence on the impact on outcomes of various methods of health care delivery (18).

### GLYCEMIC TARGETS IN PREGNANCY

#### Recommendations

**14.6** Fasting and postprandial self-monitoring of blood glucose are recommended in both gestational diabetes mellitus and preexisting diabetes in pregnancy to achieve glycemic control. Some women with preexisting

diabetes should also test blood glucose preprandially. **B**

**14.7** Due to increased red blood cell turnover, A1C is slightly lower in normal pregnancy than in normal nonpregnant women. Ideally, the A1C target in pregnancy is <6% (42 mmol/mol) if this can be achieved without significant hypoglycemia, but the target may be relaxed to <7% (53 mmol/mol) if necessary to prevent hypoglycemia. **B**

Pregnancy in women with normal glucose metabolism is characterized by fasting levels of blood glucose that are lower than in the nonpregnant state due to insulin-independent glucose uptake by the fetus and placenta and by postprandial hyperglycemia and carbohydrate intolerance as a result of diabetogenic placental hormones. In patients with preexisting diabetes, glycemic targets are usually achieved through a combination of insulin administration and medical nutrition therapy. Because glycemic targets in pregnancy are stricter than in nonpregnant individuals, it is important that women with diabetes eat consistent amounts of carbohydrates to match with insulin dosage and to avoid hyperglycemia or hypoglycemia. Referral to a registered dietitian is important in order to establish a food plan and insulin-to-carbohydrate ratio and to determine weight gain goals.

### Insulin Physiology

Early pregnancy is a time of enhanced insulin sensitivity, lower glucose levels, and lower insulin requirements in women with type 1 diabetes. The situation rapidly reverses as insulin resistance increases exponentially during the second and early third trimesters and levels off toward the end of the third trimester. In women with normal pancreatic function, insulin production is sufficient to meet the challenge of this physiological insulin resistance and to maintain normal glucose levels. However, in women with GDM or preexisting diabetes, hyperglycemia occurs if treatment is not adjusted appropriately.

### Glucose Monitoring

Reflecting this physiology, fasting and postprandial monitoring of blood glucose

is recommended to achieve metabolic control in pregnant women with diabetes. Preprandial testing is also recommended for women with preexisting diabetes using insulin pumps or basal-bolus therapy, so that premeal rapid-acting insulin dosage can be adjusted. Postprandial monitoring is associated with better glycemic control and lower risk of preeclampsia (19–21). There are no adequately powered randomized trials comparing different fasting and postmeal glycemic targets in diabetes in pregnancy.

Similar to the targets recommended by the American College of Obstetricians and Gynecologists (the same as for GDM; described below) (22), the ADA-recommended targets for women with type 1 or type 2 diabetes are as follows:

- Fasting <95 mg/dL (5.3 mmol/L) and either
- One-hour postprandial <140 mg/dL (7.8 mmol/L) or
- Two-hour postprandial <120 mg/dL (6.7 mmol/L)

These values represent optimal control if they can be achieved safely. In practice, it may be challenging for women with type 1 diabetes to achieve these targets without hypoglycemia, particularly women with a history of recurrent hypoglycemia or hypoglycemia unawareness.

If women cannot achieve these targets without significant hypoglycemia, the ADA suggests less stringent targets based on clinical experience and individualization of care.

### A1C in Pregnancy

In studies of women without preexisting diabetes, increasing A1C levels within the normal range is associated with adverse outcomes (23). In the Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study, increasing levels of glycemia were associated with worsening outcomes (24). Observational studies in preexisting diabetes and pregnancy show the lowest rates of adverse fetal outcomes in association with A1C <6–6.5% (42–48 mmol/mol) early in gestation (4–6,25). Clinical trials have not evaluated the risks and benefits of achieving these targets, and treatment goals should account for the risk of

maternal hypoglycemia in setting an individualized target of <6% (42 mmol/mol) to <7% (53 mmol/mol). Due to physiological increases in red blood cell turnover, A1C levels fall during normal pregnancy (26,27). Additionally, as A1C represents an integrated measure of glucose, it may not fully capture postprandial hyperglycemia, which drives macrosomia. Thus, although A1C may be useful, it should be used as a secondary measure of glycemic control in pregnancy, after self-monitoring of blood glucose.

In the second and third trimesters, A1C <6% (42 mmol/mol) has the lowest risk of large-for-gestational-age infants (25,28,29), preterm delivery (30), and preeclampsia (1,31). Taking all of this into account, a target of <6% (42 mmol/mol) is optimal during pregnancy if it can be achieved without significant hypoglycemia. The A1C target in a given patient should be achieved without hypoglycemia, which, in addition to the usual adverse sequelae, may increase the risk of low birth weight (32). Given the alteration in red blood cell kinetics during pregnancy and physiological changes in glycemic parameters, A1C levels may need to be monitored more frequently than usual (e.g., monthly).

## MANAGEMENT OF GESTATIONAL DIABETES MELLITUS

### Recommendations

**14.8** Lifestyle change is an essential component of management of gestational diabetes mellitus and may suffice for the treatment of many women. Medications should be added if needed to achieve glycemic targets. **A**

**14.9** Insulin is the preferred medication for treating hyperglycemia in gestational diabetes mellitus as it does not cross the placenta to a measurable extent. Metformin and glyburide should not be used as first-line agents, as both cross the placenta to the fetus. All oral agents lack long-term safety data. **A**

**14.10** Metformin, when used to treat polycystic ovary syndrome and induce ovulation, should be discontinued once pregnancy has been confirmed. **A**

GDM is characterized by increased risk of macrosomia and birth complications and an increased risk of maternal type 2 diabetes after pregnancy. The association of macrosomia and birth complications with oral glucose tolerance test (OGTT) results is continuous with no clear inflection points (24). In other words, risks increase with progressive hyperglycemia. Therefore, all women should be tested as outlined in Section 2 “Classification and Diagnosis of Diabetes.” Although there is some heterogeneity, many randomized controlled trials (RCTs) suggest that the risk of GDM may be reduced by diet, exercise, and lifestyle counseling, particularly when interventions are started during the first or early in the second trimester (33–35).

### Lifestyle Management

After diagnosis, treatment starts with medical nutrition therapy, physical activity, and weight management depending on pregestational weight, as outlined in the section below on preexisting type 2 diabetes, and glucose monitoring aiming for the targets recommended by the Fifth International Workshop-Conference on Gestational Diabetes Mellitus (36):

- Fasting <95 mg/dL (5.3 mmol/L) and either
- One-hour postprandial <140 mg/dL (7.8 mmol/L) or
- Two-hour postprandial <120 mg/dL (6.7 mmol/L)

Depending on the population, studies suggest that 70–85% of women diagnosed with GDM under Carpenter-Coustan or National Diabetes Data Group (NDDG) criteria can control GDM with lifestyle modification alone; it is anticipated that this proportion will be even higher if the lower International Association of Diabetes and Pregnancy Study Groups (IADPSG) (37) diagnostic thresholds are used.

### Medical Nutrition Therapy

Medical nutrition therapy for GDM is an individualized nutrition plan developed between the woman and a registered dietitian familiar with the management of GDM (38,39). The food plan should provide adequate calorie intake to promote fetal/neonatal and maternal health, achieve glycemic goals, and promote appropriate gestational weight

gain. There is no definitive research that identifies a specific optimal calorie intake for women with GDM or suggests that their calorie needs are different from those of pregnant women without GDM. The food plan should be based on a nutrition assessment with guidance from the Dietary Reference Intakes (DRI). The DRI for all pregnant women recommends a minimum of 175 g of carbohydrate, a minimum of 71 g of protein, and 28 g of fiber. As is true for all nutrition therapy in patients with diabetes, the amount and type of carbohydrate will impact glucose levels, especially postmeal excursions.

### Pharmacologic Therapy

Treatment of GDM with lifestyle and insulin has been demonstrated to improve perinatal outcomes in two large randomized studies as summarized in a U.S. Preventive Services Task Force review (40). Insulin is the first-line agent recommended for treatment of GDM in the U.S. While individual RCTs support limited efficacy of metformin (41,42) and glyburide (43) in reducing glucose levels for the treatment of GDM, these agents are not recommended as first-line treatment for GDM because they are known to cross the placenta and data on safety for offspring is lacking (22). Furthermore, in two RCTs, glyburide and metformin failed to provide adequate glycemic control in 23% and 25–28%, respectively (44,45), of women with GDM.

### Sulfonylureas

Sulfonylureas are known to cross the placenta and have been associated with increased neonatal hypoglycemia. Concentrations of glyburide in umbilical cord plasma are approximately 70% of maternal levels (44,45). Glyburide was associated with a higher rate of neonatal hypoglycemia and macrosomia than insulin or metformin in a 2015 meta-analysis and systematic review (46). More recently, glyburide failed to be found noninferior to insulin based on a composite outcome of neonatal hypoglycemia, macrosomia, and hyperbilirubinemia. Long-term safety data for offspring are not available (47,48).

### Metformin

Metformin was associated with a lower risk of neonatal hypoglycemia and less maternal weight gain than insulin in

systematic reviews (46,49,50); however, metformin may slightly increase the risk of prematurity. Like glyburide, metformin crosses the placenta, and umbilical cord blood levels of metformin are higher than simultaneous maternal levels (51,52). In the Metformin in Gestational Diabetes: The Offspring Follow-Up (MiG TOFU) study's analyses of 7- to 9-year-old offspring, 9-year-old offspring exposed to metformin for the treatment of GDM were larger (based on a number of measurements) than those exposed to insulin (53). In two RCTs of metformin use in pregnancy for polycystic ovary syndrome, follow-up of 4-year-old offspring demonstrated higher BMI and increased obesity in the offspring exposed to metformin (53,54). Further study of long-term outcomes in the offspring is needed (53,54).

Randomized, double-blind, controlled trials comparing metformin with other therapies for ovulation induction in women with polycystic ovary syndrome have not demonstrated benefit in preventing spontaneous abortion or GDM (55), and there is no evidence-based need to continue metformin in such patients once pregnancy has been confirmed (56–58).

### Insulin

Insulin use should follow the guidelines below. Both multiple daily insulin injections and continuous subcutaneous insulin infusion are reasonable delivery strategies, and neither has been shown to be superior during pregnancy (59).

## MANAGEMENT OF PREEXISTING TYPE 1 DIABETES AND TYPE 2 DIABETES IN PREGNANCY

### Insulin Use

#### Recommendation

**14.11** Insulin is the preferred agent for management of both type 1 diabetes and type 2 diabetes in pregnancy because it does not cross the placenta and because oral agents are generally insufficient to overcome the insulin resistance in type 2 diabetes and are ineffective in type 1 diabetes. **E**

The physiology of pregnancy necessitates frequent titration of insulin to match changing requirements and underscores the importance of daily

and frequent self-monitoring of blood glucose. Early in the first trimester, there is an increase in insulin requirements, followed by a decrease in weeks 9 through 16 (60). Women, particularly those with type 1 diabetes, may experience increased hypoglycemia. After 16 weeks, rapidly increasing insulin resistance requires weekly increases in insulin dose of about 5% per week to achieve glycemic targets. There is roughly a doubling of insulin requirements by the late third trimester. In general, a smaller proportion of the total daily dose should be given as basal insulin (<50%) and a greater proportion (>50%) as prandial insulin. Late in the third trimester, there is often a leveling off or small decrease in insulin requirements. Due to the complexity of insulin management in pregnancy, referral to a specialized center offering team-based care (with team members including maternal-fetal medicine specialist, endocrinologist, or other provider experienced in managing pregnancy in women with preexisting diabetes, dietitian, nurse, and social worker, as needed) is recommended if this resource is available.

None of the currently available human insulin preparations have been demonstrated to cross the placenta (61–66).

A recent Cochrane systematic review was not able to recommend any specific insulin regimen over another for the treatment of diabetes in pregnancy (67).

### Preeclampsia and Aspirin

#### Recommendation

**14.12** Women with type 1 or type 2 diabetes should be prescribed low-dose aspirin 60–150 mg/day (usual dose 81 mg/day) from the end of the first trimester until the baby is born in order to lower the risk of preeclampsia. **A**

Diabetes in pregnancy is associated with an increased risk of preeclampsia (68). Based upon the results of clinical trials, the U.S. Preventive Services Task Force recommends the use of low-dose aspirin (81 mg/day) as a preventive medication after 12 weeks of gestation in women who are at high risk for preeclampsia (69). A cost-benefit analysis

has concluded that this approach would reduce morbidity, save lives, and lower health care costs (70).

### Type 1 Diabetes

Women with type 1 diabetes have an increased risk of hypoglycemia in the first trimester and, like all women, have altered counterregulatory response in pregnancy that may decrease hypoglycemia awareness. Education for patients and family members about the prevention, recognition, and treatment of hypoglycemia is important before, during, and after pregnancy to help to prevent and manage the risks of hypoglycemia. Insulin resistance drops rapidly with delivery of the placenta. Women become very insulin sensitive immediately following delivery and may initially require much less insulin than in the prepartum period.

Pregnancy is a ketogenic state, and women with type 1 diabetes, and to a lesser extent those with type 2 diabetes, are at risk for diabetic ketoacidosis at lower blood glucose levels than in the nonpregnant state. Women with preexisting diabetes, especially type 1 diabetes, need ketone strips at home and education on diabetic ketoacidosis prevention and detection. In addition, rapid implementation of tight glycemic control in the setting of retinopathy is associated with worsening of retinopathy (13).

The role of continuous glucose monitoring in pregnancies impacted by diabetes is still being studied. In one RCT, continuous glucose monitoring use in pregnancies complicated by type 1 diabetes showed improved neonatal outcomes and a slight reduction in A1C, but interestingly no difference in severe hypoglycemic events compared with control subjects (71).

### Type 2 Diabetes

Type 2 diabetes is often associated with obesity. Recommended weight gain during pregnancy for overweight women is 15–25 lb and for obese women is 10–20 lb (72). Glycemic control is often easier to achieve in women with type 2 diabetes than in those with type 1 diabetes but can require much higher doses of insulin, sometimes necessitating concentrated insulin formulations. As in type 1 diabetes, insulin requirements drop dramatically after delivery. The risk for associated hypertension and other comorbidities

may be as high or higher with type 2 diabetes as with type 1 diabetes, even if diabetes is better controlled and of shorter apparent duration, with pregnancy loss appearing to be more prevalent in the third trimester in women with type 2 diabetes compared with the first trimester in women with type 1 diabetes (73,74).

## PREGNANCY AND DRUG CONSIDERATIONS

### Recommendations

**14.13** In pregnant patients with diabetes and chronic hypertension, blood pressure targets of 120–160/80–105 mmHg are suggested in the interest of optimizing long-term maternal health and minimizing impaired fetal growth. **E**

**14.14** Potentially teratogenic medications (i.e., ACE inhibitors, angiotensin receptor blockers, statins) should be avoided in sexually active women of child-bearing age who are not using reliable contraception. **B**

In normal pregnancy, blood pressure is lower than in the nonpregnant state. In a pregnancy complicated by diabetes and chronic hypertension, target goals for systolic blood pressure 120–160 mmHg and diastolic blood pressure 80–105 mmHg are reasonable (75). Lower blood pressure levels may be associated with impaired fetal growth. In a 2015 study targeting diastolic blood pressure of 100 mmHg versus 85 mmHg in pregnant women, only 6% of whom had GDM at enrollment, there was no difference in pregnancy loss, neonatal care, or other neonatal outcomes, although women in the less intensive treatment group had a higher rate of uncontrolled hypertension (76).

During pregnancy, treatment with ACE inhibitors and angiotensin receptor blockers is contraindicated because they may cause fetal renal dysplasia, oligohydramnios, and intrauterine growth restriction (10). Antihypertensive drugs known to be effective and safe in pregnancy include methyldopa, nifedipine, labetalol, diltiazem, clonidine, and prazosin. Atenolol is not recommended. Chronic diuretic use during pregnancy

is not recommended as it has been associated with restricted maternal plasma volume, which may reduce uteroplacental perfusion (77). On the basis of available evidence, statins should also be avoided in pregnancy (78).

*Please see PREGNANCY AND ANTIHYPERTENSIVE MEDICATIONS in Section 10 “Cardiovascular Disease and Risk Management” for more information on managing blood pressure in pregnancy.*

## POSTPARTUM CARE

Postpartum care should include psychosocial assessment and support for self-care.

### Lactation

In light of the immediate nutritional and immunological benefits of breastfeeding for the baby, all women including those with diabetes should be supported in attempts to breastfeed. Breastfeeding may also confer longer-term metabolic benefits to both mother (79) and offspring (80).

## Gestational Diabetes Mellitus

### Initial Testing

Because GDM may represent preexisting undiagnosed type 2 or even type 1 diabetes, women with GDM should be tested for persistent diabetes or prediabetes at 4–12 weeks postpartum with a 75-g OGTT using nonpregnancy criteria as outlined in Section 2 “Classification and Diagnosis of Diabetes.”

### Postpartum Follow-up

The OGTT is recommended over A1C at the time of the 4- to 12-week postpartum visit because A1C may be persistently impacted (lowered) by the increased red blood cell turnover related to pregnancy or blood loss at delivery and because the OGTT is more sensitive at detecting glucose intolerance, including both prediabetes and diabetes. Reproductive-aged women with prediabetes may develop type 2 diabetes by the time of their next pregnancy and will need preconception evaluation. Because GDM is associated with an increased lifetime maternal risk for diabetes estimated at 50–70% after 15–25 years (81,82), women should also be tested every 1–3 years thereafter if the 4- to 12-week postpartum 75-g OGTT is normal, with frequency of testing depending on other risk factors including family history,

prepregnancy BMI, and need for insulin or oral glucose-lowering medication during pregnancy. Ongoing evaluation may be performed with any recommended glycemic test (e.g., A1C, fasting plasma glucose, or 75-g OGTT using nonpregnant thresholds).

#### **Gestational Diabetes Mellitus and Type 2 Diabetes**

Women with a history of GDM have a greatly increased risk of conversion to type 2 diabetes over time (81). In the prospective Nurses' Health Study II (NHS II), subsequent diabetes risk after a history of GDM was significantly lower in women who followed healthy eating patterns (83). Adjusting for BMI moderately, but not completely, attenuated this association. Interpregnancy or postpartum weight gain is associated with increased risk of adverse pregnancy outcomes in subsequent pregnancies (84) and earlier progression to type 2 diabetes.

Both metformin and intensive lifestyle intervention prevent or delay progression to diabetes in women with prediabetes and a history of GDM. Of women with a history of GDM and prediabetes, only 5–6 women need to be treated with either intervention to prevent one case of diabetes over 3 years (85). In these women, lifestyle intervention and metformin reduced progression to diabetes by 35% and 40%, respectively, over 10 years compared with placebo (86). If the pregnancy has motivated the adoption of a healthier diet, building on these gains to support weight loss is recommended in the postpartum period.

#### **Preexisting Type 1 and Type 2 Diabetes**

Insulin sensitivity increases dramatically with delivery of the placenta. Thus, insulin requirements in the immediate postpartum period are roughly 34% lower than prepregnancy insulin requirements (87). Insulin sensitivity then returns to prepregnancy levels over the following 1–2 weeks. In women taking insulin, particular attention should be directed to hypoglycemia prevention in the setting of breastfeeding and erratic sleep and eating schedules (88).

#### **Contraception**

A major barrier to effective preconception care is the fact that the majority of pregnancies are unplanned. Planning

pregnancy is critical in women with pre-existing diabetes due to the need for preconception glycemic control to prevent congenital malformations and reduce the risk of other complications. Therefore, all women with diabetes of childbearing potential should have family planning options reviewed at regular intervals. This applies to women in the immediate postpartum period. Women with diabetes have the same contraception options and recommendations as those without diabetes. The risk of an unplanned pregnancy outweighs the risk of any given contraception option.

#### **References**

- Holmes VA, Young IS, Patterson CC, et al.; Diabetes and Pre-eclampsia Intervention Trial Study Group. Optimal glycemic control, pre-eclampsia, and gestational hypertension in women with type 1 diabetes in the Diabetes and Pre-eclampsia Intervention Trial. *Diabetes Care* 2011;34:1683–1688
- Dabelea D, Hanson RL, Lindsay RS, et al. Intrauterine exposure to diabetes conveys risks for type 2 diabetes and obesity: a study of discordant sibships. *Diabetes* 2000;49:2208–2211
- Guerin A, Nisenbaum R, Ray JG. Use of maternal GHB concentration to estimate the risk of congenital anomalies in the offspring of women with prepregnancy diabetes. *Diabetes Care* 2007;30:1920–1925
- Jensen DM, Korsholm L, Ovesen P, et al. Peri-conceptual A1C and risk of serious adverse pregnancy outcome in 933 women with type 1 diabetes. *Diabetes Care* 2009;32:1046–1048
- Nielsen GL, Møller M, Sørensen HT. HbA1c in early diabetic pregnancy and pregnancy outcomes: a Danish population-based cohort study of 573 pregnancies in women with type 1 diabetes. *Diabetes Care* 2006;29:2612–2616
- Suhonen L, Hiilesmaa V, Teramo K. Glycaemic control during early pregnancy and fetal malformations in women with type 1 diabetes mellitus. *Diabetologia* 2000;43:79–82
- Charron-Prochownik D, Sereika SM, Becker D, et al. Long-term effects of the booster-enhanced READY-Girls preconception counseling program on intentions and behaviors for family planning in teens with diabetes. *Diabetes Care* 2013;36:3870–3874
- Peterson C, Grosse SD, Li R, et al. Preventable health and cost burden of adverse birth outcomes associated with pregestational diabetes in the United States. *Am J Obstet Gynecol* 2015;212:74.e1–74.e9
- Charron-Prochownik D, Downs J. *Diabetes and Reproductive Health for Girls*. Alexandria, VA, American Diabetes Association, 2016
- Bullo M, Tschumi S, Bucher BS, Bianchetti MG, Simonetti GD. Pregnancy outcome following exposure to angiotensin-converting enzyme inhibitors or angiotensin receptor antagonists: a systematic review. *Hypertension* 2012;60:444–450
- Taguchi N, Rubin ET, Hosokawa A, et al. Prenatal exposure to HMG-CoA reductase inhibitors: effects on fetal and neonatal outcomes. *Reprod Toxicol* 2008;26:175–177
- Bateman BT, Hernandez-Diaz S, Fischer MA, et al. Statins and congenital malformations: cohort study. *BMJ* 2015;350:h1035
- Chew EY, Mills JL, Metzger BE, et al.; National Institute of Child Health and Human Development Diabetes in Early Pregnancy Study. Metabolic control and progression of retinopathy: the Diabetes in Early Pregnancy Study. *Diabetes Care* 1995;18:631–637
- McElvy SS, Miodovnik M, Rosenn B, et al. A focused preconceptional and early pregnancy program in women with type 1 diabetes reduces perinatal mortality and malformation rates to general population levels. *J Matern Fetal Med* 2000;9:14–20
- Murphy HR, Roland JM, Skinner TC, et al. Effectiveness of a regional pregnancy care program in women with type 1 and type 2 diabetes: benefits beyond glycemic control. *Diabetes Care* 2010;33:2514–2520
- Elixhauser A, Weschler JM, Kitzmiller JL, et al. Cost-benefit analysis of preconception care for women with established diabetes mellitus. *Diabetes Care* 1993;16:1146–1157
- Owens LA, Avalos G, Kirwan B, Carmody L, Dunne F. ATLANTIC DIP: closing the loop: a change in clinical practice can improve outcomes for women with pregestational diabetes. *Diabetes Care* 2012;35:1669–1671
- Taylor C, McCance DR, Chappell L, Nelson-Piercy C, Thorne SA, Ismail KMK, et al. Implementation of guidelines for multidisciplinary team management of pregnancy in women with pre-existing diabetes or cardiac conditions: results from a UK national survey. *BMC Pregnancy Childbirth* 2017;17:434
- Manderson JG, Patterson CC, Hadden DR, Traub AI, Ennis C, McCance DR. Preprandial versus postprandial blood glucose monitoring in type 1 diabetic pregnancy: a randomized controlled clinical trial. *Am J Obstet Gynecol* 2003;189:507–512
- de Veciana M, Major CA, Morgan MA, et al. Postprandial versus preprandial blood glucose monitoring in women with gestational diabetes mellitus requiring insulin therapy. *N Engl J Med* 1995;333:1237–1241
- Jovanovic-Peterson L, Peterson CM, Reed GF, et al. Maternal postprandial glucose levels and infant birth weight: the Diabetes in Early Pregnancy Study. The National Institute of Child Health and Human Development—Diabetes in Early Pregnancy Study. *Am J Obstet Gynecol* 1991;164:103–111
- Committee on Practice Bulletins—Obstetrics. ACOG Practice Bulletin No. 190: Gestational Diabetes Mellitus. *Obstet Gynecol* 2018;131:e49–e64
- Ho Y-R, Wang P, Lu M-C, Tseng S-T, Yang C-P, Yan Y-H. Associations of mid-pregnancy HbA1c with gestational diabetes and risk of adverse pregnancy outcomes in high-risk Taiwanese women. *PLoS One* 2017;12:e0177563
- Metzger BE, Lowe LP, Dyer AR, et al.; HAPO Study Cooperative Research Group. Hyperglycemia and adverse pregnancy outcomes. *N Engl J Med* 2008;358:1991–2002
- Mareesh MJA, Holmes VA, Patterson CC, et al.; Diabetes and Pre-eclampsia Intervention Trial Study Group. Glycemic targets in the second and

- third trimester of pregnancy for women with type 1 diabetes. *Diabetes Care* 2015;38:34–42
26. Nielsen LR, Ekbom P, Damm P, et al. HbA1c levels are significantly lower in early and late pregnancy. *Diabetes Care* 2004;27:1200–1201
27. Mosca A, Paleari R, Dalfrà MG, et al. Reference intervals for hemoglobin A1c in pregnant women: data from an Italian multicenter study. *Clin Chem* 2006;52:1138–1143
28. Hummel M, Marienfeld S, Huppmann M, et al. Fetal growth is increased by maternal type 1 diabetes and HLA DR4-related gene interactions. *Diabetologia* 2007;50:850–858
29. Cyganek K, Skupien J, Katra B, et al. Risk of macrosomia remains glucose-dependent in a cohort of women with pregestational type 1 diabetes and good glycemic control. *Endocrine* 2017;55:447–455
30. Abell SK, Boyle JA, de Courten B, et al. Impact of type 2 diabetes, obesity and glycaemic control on pregnancy outcomes. *Aust N Z J Obstet Gynaecol* 2017;57:308–314
31. Temple RC, Aldridge V, Stanley K, Murphy HR. Glycaemic control throughout pregnancy and risk of pre-eclampsia in women with type 1 diabetes. *BJOG* 2006;113:1329–1332
32. Combs CA, Gunderson E, Kitzmiller JL, Gavin LA, Main EK. Relationship of fetal macrosomia to maternal postprandial glucose control during pregnancy. *Diabetes Care* 1992;15:1251–1257
33. Bain E, Crane M, Tieu J, Han S, Crowther CA, Middleton P. Diet and exercise interventions for preventing gestational diabetes mellitus. *Cochrane Database Syst Rev* 2015;4:CD010443
34. Koivusalo SB, Rönö K, Klemetti MM, et al. Gestational diabetes mellitus can be prevented by lifestyle intervention: the Finnish Gestational Diabetes Prevention Study (RADIEL): a randomized controlled trial. *Diabetes Care* 2016;39:24–30
35. Wang C, Wei Y, Zhang X, et al. A randomized clinical trial of exercise during pregnancy to prevent gestational diabetes mellitus and improve pregnancy outcome in overweight and obese pregnant women. *Am J Obstet Gynecol* 2017;216:340–351
36. Metzger BE, Buchanan TA, Coustan DR, et al. Summary and recommendations of the Fifth International Workshop-Conference on Gestational Diabetes Mellitus. *Diabetes Care*;2007;30 (Suppl. 2):S251–S260
37. Mayo K, Melamed N, Vandenberghe H, Berger H. The impact of adoption of the International Association of Diabetes in Pregnancy Study Group criteria for the screening and diagnosis of gestational diabetes. *Am J Obstet Gynecol* 2015;212:224.e1–224.e9
38. Han S, Crowther CA, Middleton P, Heatley E. Different types of dietary advice for women with gestational diabetes mellitus. *Cochrane Database Syst Rev* 2013;3:CD009275
39. Viana LV, Gross JL, Azevedo MJ. Dietary intervention in patients with gestational diabetes mellitus: a systematic review and meta-analysis of randomized clinical trials on maternal and newborn outcomes. *Diabetes Care* 2014;37:3345–3355
40. Hartling L, Dryden DM, Guthrie A, Muise M, Vandermeer B, Donovan L. Benefits and harms of treating gestational diabetes mellitus: a systematic review and meta-analysis for the U.S. Preventive Services Task Force and the National Institutes of Health Office of Medical Applications of Research. *Ann Intern Med* 2013;159:123–129
41. Rowan JA, Hague WM, Gao W, Battin MR, Moore MP; MiG Trial Investigators. Metformin versus insulin for the treatment of gestational diabetes. *N Engl J Med* 2008;358:2003–2015
42. Gui J, Liu Q, Feng L. Metformin vs insulin in the management of gestational diabetes: a meta-analysis. *PLoS One* 2013;8:e64585
43. Langer O, Conway DL, Berkus MD, Xenakis EM-J, Gonzales O. A comparison of glyburide and insulin in women with gestational diabetes mellitus. *N Engl J Med* 2000;343:1134–1138
44. Hebert MF, Ma X, Naraharsetti SB, et al.; Obstetric-Fetal Pharmacology Research Unit Network. Are we optimizing gestational diabetes treatment with glyburide? The pharmacologic basis for better clinical practice. *Clin Pharmacol Ther* 2009;85:607–614
45. Malek R, Davis SN. Pharmacokinetics, efficacy and safety of glyburide for treatment of gestational diabetes mellitus. *Expert Opin Drug Metab Toxicol* 2016;12:691–699
46. Balsells M, García-Patterson A, Solà I, Roqué M, Gich I, Corcoy R. Glibenclamide, metformin, and insulin for the treatment of gestational diabetes: a systematic review and meta-analysis. *BMJ* 2015;350:h102
47. Coustan DR. Pharmacological management of gestational diabetes: an overview. *Diabetes Care* 2007;30(Suppl. 2):S206–S208
48. Sénat M-V, Affres H, Letourneau A, et al.; Groupe de Recherche en Obstétrique et Gynécologie (GROG). Effect of glyburide vs subcutaneous insulin on perinatal complications among women with gestational diabetes: a randomized clinical trial. *JAMA* 2018;319:1773–1780
49. Jiang Y-F, Chen X-Y, Ding T, Wang X-F, Zhu Z-N, Su S-W. Comparative efficacy and safety of OADs in management of GDM: network meta-analysis of randomized controlled trials. *J Clin Endocrinol Metab* 2015;100:2071–2080
50. Camelo Castillo W, Boggess K, Stürmer T, Brookhart MA, Benjamin DK Jr, Jonsson Funk M. Association of adverse pregnancy outcomes with glyburide vs insulin in women with gestational diabetes. *JAMA Pediatr* 2015;169:452–458
51. Vanky E, Zahlsen K, Spigset O, Carlsen SM. Placental passage of metformin in women with polycystic ovary syndrome. *Fertil Steril* 2005;83:1575–1578
52. Charles B, Norris R, Xiao X, Hague W. Population pharmacokinetics of metformin in late pregnancy. *Ther Drug Monit* 2006;28:67–72
53. Rowan JA, Rush EC, Plank LD, et al. Metformin in Gestational Diabetes: The Offspring Follow-Up (MiG TOFU): body composition and metabolic outcomes at 7-9 years of age. *BMJ Open Diabetes Res Care* 2018;6:e000456
54. Hanem LGE, Stridsklev S, Júlíusson PB, et al. Metformin use in PCOS pregnancies increases the risk of offspring overweight at 4 years of age: follow-up of two RCTs. *J Clin Endocrinol Metab* 2018;103:1612–1621
55. Vanky E, Stridsklev S, Heimstad R, et al. Metformin versus placebo from first trimester to delivery in polycystic ovary syndrome: a randomized, controlled multicenter study. *J Clin Endocrinol Metab* 2010;95:E448–E455
56. Legro RS, Barnhart HX, Schlaff WD, et al.; Cooperative Multicenter Reproductive Medicine Network. Clomiphene, metformin, or both for infertility in the polycystic ovary syndrome. *N Engl J Med* 2007;356:551–566
57. Palomba S, Orio F Jr, Falbo A, et al. Prospective parallel randomized, double-blind, double-dummy controlled clinical trial comparing clomiphene citrate and metformin as the first-line treatment for ovulation induction in non-obese anovulatory women with polycystic ovary syndrome. *J Clin Endocrinol Metab* 2005;90:4068–4074
58. Palomba S, Orio F Jr, Nardo LG, et al. Metformin administration versus laparoscopic ovarian diathermy in clomiphene citrate-resistant women with polycystic ovary syndrome: a prospective parallel randomized double-blind placebo-controlled trial. *J Clin Endocrinol Metab* 2004;89:4801–4809
59. Farrar D, Tuffnell DJ, West J, West HM. Continuous subcutaneous insulin infusion versus multiple daily injections of insulin for pregnant women with diabetes. *Cochrane Database Syst Rev* 2016;6:CD005542
60. García-Patterson A, Gich I, Amini SB, Catalano PM, de Leiva A, Corcoy R. Insulin requirements throughout pregnancy in women with type 1 diabetes mellitus: three changes of direction. *Diabetologia* 2010;53:446–451
61. Menon RK, Cohen RM, Sperling MA, Cutfield WS, Mimouni F, Khoury JC. Transplacental passage of insulin in pregnant women with insulin-dependent diabetes mellitus. Its role in fetal macrosomia. *N Engl J Med* 1990;323:309–315
62. Pollex EK, Feig DS, Lubetsky A, Yip PM, Koren G. Insulin glargine safety in pregnancy: a transplacental transfer study. *Diabetes Care* 2010;33:29–33
63. Holcberg G, Tsadkin-Tamir M, Sapir O, et al. Transfer of insulin lispro across the human placenta. *Eur J Obstet Gynecol Reprod Biol* 2004;115:117–118
64. Boskovic R, Feig DS, Derewlany L, Knie B, Portnoi G, Koren G. Transfer of insulin lispro across the human placenta: in vitro perfusion studies. *Diabetes Care* 2003;26:1390–1394
65. McCance DR, Damm P, Mathiesen ER, et al. Evaluation of insulin antibodies and placental transfer of insulin aspart in pregnant women with type 1 diabetes mellitus. *Diabetologia* 2008;51:2141–2143
66. Suffecool K, Rosenn B, Niederkofler EE, et al. Insulin detemir does not cross the human placenta. *Diabetes Care* 2015;38:e20–e21
67. O'Neill SM, Kenny LC, Khoshan AS, West HM, Smyth RM, Kearney PM. Different insulin types and regimens for pregnant women with pre-existing diabetes. *Cochrane Database Syst Rev* 2017;2:CD011880
68. Duckitt K, Harrington D. Risk factors for pre-eclampsia at antenatal booking: systematic review of controlled studies. *BMJ* 2005;330:565
69. Henderson JT, Whitlock EP, O'Conner E, Senger CA, Thompson JH, Rowland MG. Low-dose aspirin for the prevention of morbidity and mortality from preeclampsia: a systematic evidence review for the U.S. Preventive Services Task Force, 2014. Rockville, MD, Agency for Healthcare Research and Quality (Report No. 14-05207-EF-1)

70. Werner EF, Hauspurg AK, Rouse DJ. A cost-benefit analysis of low-dose aspirin prophylaxis for the prevention of preeclampsia in the United States. *Obstet Gynecol* 2015;126:1242–1250
71. Feig DS, Donovan LE, Corcoy R, et al.; CONCEPTT Collaborative Group. Continuous glucose monitoring in pregnant women with type 1 diabetes (CONCEPTT): a multicentre international randomised controlled trial. *Lancet* 2017;390:2347–2359
72. Institute of Medicine and National Research Council. *Weight Gain During Pregnancy: Re-examining the Guidelines*. Washington, DC, National Academies Press, 2009
73. Clausen TD, Mathiesen E, Ekbohm P, Hellmuth E, Mandrup-Poulsen T, Damm P. Poor pregnancy outcome in women with type 2 diabetes. *Diabetes Care* 2005;28:323–328
74. Cundy T, Gamble G, Neale L, et al. Differing causes of pregnancy loss in type 1 and type 2 diabetes. *Diabetes Care* 2007;30:2603–2607
75. American College of Obstetricians and Gynecologists; Task Force on Hypertension in Pregnancy. Hypertension in pregnancy. Report of the American College of Obstetricians and Gynecologists' Task Force on Hypertension in Pregnancy. *Obstet Gynecol* 2013;122:1122–1131
76. Magee LA, von Dadelszen P, Rey E, et al. Less-tight versus tight control of hypertension in pregnancy. *N Engl J Med* 2015;372:407–417
77. Sibai BM. Treatment of hypertension in pregnant women. *N Engl J Med* 1996;335:257–265
78. Kazmin A, Garcia-Bournissen F, Koren G. Risks of statin use during pregnancy: a systematic review. *J Obstet Gynaecol Can* 2007;29:906–908
79. Stuebe AM, Rich-Edwards JW, Willett WC, Manson JE, Michels KB. Duration of lactation and incidence of type 2 diabetes. *JAMA* 2005;294:2601–2610
80. Pereira PF, Alfenas Rde CG, Araújo RMA. Does breastfeeding influence the risk of developing diabetes mellitus in children? A review of current evidence. *J Pediatr (Rio J)* 2014;90:7–15
81. Kim C, Newton KM, Knopp RH. Gestational diabetes and the incidence of type 2 diabetes: a systematic review. *Diabetes Care* 2002;25:1862–1868
82. Drury MI. Carbohydrate metabolism in pregnancy and the newborn. Sutherland HW, Stowers JM, Eds. Edinburgh, Churchill Livingstone, 1984
83. Tobias DK, Hu FB, Chavarro J, Rosner B, Mozaffarian D, Zhang C. Healthful dietary patterns and type 2 diabetes mellitus risk among women with a history of gestational diabetes mellitus. *Arch Intern Med* 2012;172:1566–1572
84. Villamor E, Cnattingius S. Interpregnancy weight change and risk of adverse pregnancy outcomes: a population-based study. *Lancet* 2006;368:1164–1170
85. Ratner RE, Christophi CA, Metzger BE, et al.; Diabetes Prevention Program Research Group. Prevention of diabetes in women with a history of gestational diabetes: effects of metformin and lifestyle interventions. *J Clin Endocrinol Metab* 2008;93:4774–4779
86. Aroda VR, Christophi CA, Edelstein SL, et al.; Diabetes Prevention Program Research Group. The effect of lifestyle intervention and metformin on preventing or delaying diabetes among women with and without gestational diabetes: the Diabetes Prevention Program Outcomes Study 10-year follow-up. *J Clin Endocrinol Metab* 2015;100:1646–1653
87. Roeder HA, Moore TR, Ramos GA. Changes in postpartum insulin requirements for patients with well-controlled type 1 diabetes. *Am J Perinatol* 2016;33:683–687
88. Riviello C, Mello G, Jovanovic LG. Breastfeeding and the basal insulin requirement in type 1 diabetic women. *Endocr Pract* 2009;15:187–193