

Gestational Diabetes Mellitus: Update on Screening, Diagnosis, and Management

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Gestational diabetes mellitus (GDM) is a common condition of pregnancy with increasing prevalence in the United States. GDM increases risks of complications, including operative delivery, hypertensive disorders, shoulder dystocia, fetal macrosomia, large-for-gestational-age infants, neonatal hypoglycemia, and neonatal respiratory distress. In patients who are overweight or obese, prepregnancy weight loss and lifestyle modifications during pregnancy may prevent GDM. First-trimester screening can identify preexisting diabetes and early-onset GDM for prompt implementation of glucose control measures. Treatment of GDM has been shown to reduce the risk of complications and should start with lifestyle modifications. For patients who are unable to maintain euglycemia with lifestyle modifications alone, insulin is the recommended first-line medication. For patients with poor glucose control or who require medications, fetal surveillance is suggested starting at 32 weeks of gestation. For all patients with GDM, physicians should assess for fetal macrosomia (estimated fetal weight more than 4,000 g) and discuss the risks and benefits of prelabor cesarean delivery if the estimated fetal weight is more than 4,500 g. Delivery during the 39th week of gestation may provide the best balance of maternal and fetal outcomes. The recommended delivery range for patients controlling their glucose levels with lifestyle modifications alone is 39/0 to 40/6 weeks of gestation, and the ideal range for those controlling glucose levels with medications is 39/0 to 39/6 weeks of gestation. Practice patterns vary, but evidence suggests that glucose management during labor can safely include decreased glucose testing and sliding-scale dosing of insulin as an alternative to a continuous intravenous drip. Insulin resistance typically resolves after delivery; however, patients with GDM have an increased risk of developing overt diabetes. Continued lifestyle modifications, breastfeeding, and use of metformin can reduce this risk. (*Am Fam Physician*. 2023;108(3):249-258. Copyright © 2023 American Academy of Family Physicians.)

Gestational diabetes mellitus (GDM) is glucose intolerance that is first recognized during pregnancy and suggests underlying beta cell dysfunction.¹ GDM affects up to 1 in 11 pregnancies in the United States.² As rates of inactivity, overweight/obesity, and advanced maternal age have increased, so has the incidence of GDM, which nearly doubled from 2006 to 2017.³ GDM increases the risk of numerous obstetric complications, including operative delivery, hypertensive disorders, shoulder dystocia, fetal macrosomia (estimated fetal weight more than 4,000 g), large-for-gestational-age (LGA) infants (those above the 90th percentile in weight for gestational age), neonatal hypoglycemia, and respiratory distress. Adequate glucose control reduces many of these risks.³ Patients requiring only lifestyle changes to achieve euglycemia are designated as having A1GDM, whereas those requiring medications are designated as having A2GDM.⁴

Prevention

Studies examining weight changes among pregnancies suggest that even a preconception decrease in body mass index (BMI) of only 1 kg per m² reduces the risk of developing GDM.⁵ Although prepregnancy weight loss appears to be effective, weight loss during pregnancy is not recommended due to the risk of small-for-gestational-age infants.⁶ A Cochrane review of interventions during pregnancy concluded that receiving lifestyle advice and exercising can reduce the risk of GDM, but either intervention alone is not effective.⁷ Additionally, this review noted only low-quality evidence supporting the use of vitamin D and *myo*-inositol for GDM prevention.⁷ High-quality studies are needed to investigate the effect of *myo*-inositol, vitamin D, probiotics, metformin, and dietary and exercise interventions on the development of GDM.

Screening

Screening for GDM in pregnant patients without known diabetes is recommended at 24 to 28 weeks of gestation.^{1,2,4} Retrospective observational studies of second-trimester screening have shown that it reduces the risk of cesarean

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SORT: KEY RECOMMENDATIONS FOR PRACTICE

Clinical recommendation	Evidence rating	Comments
Pregnant patients should exercise and receive lifestyle advice to prevent GDM. ⁷	C	Low-quality, disease-oriented evidence
Screen pregnant patients without known diabetes for GDM at 24 to 28 weeks of gestation. ^{1,2,4}	B	Practice guidelines based on systematic reviews; U.S. Preventive Services Task Force B recommendation
Consider screening for preexisting and early-onset GDM at initiation of pregnancy care in patients who are overweight or obese and have one additional diabetes risk factor. ^{1,4}	C	Practice guidelines based primarily on expert opinion
Initial treatment of GDM should include glucose monitoring and targeted education on nutrition and exercise. ^{4,25,31,32,34,35}	C	Practice guidelines based on meta-analysis of RCTs
Although insulin is the preferred medication for treating GDM, metformin may be used instead after discussion of potential risks and benefits; glyburide can be considered as a third-line option. ^{4,25,27,41-44}	B	Meta-analyses demonstrating improved perinatal outcomes with metformin; there is inconsistency among guidelines due to concerns of potential long-term risks
Consider induction at or after 39 weeks of gestation for patients with GDM. Induction is recommended before 41 weeks in those with diet-controlled GDM and before 40 weeks in those with medication-controlled GDM. ^{4,59-62}	C	Consensus guidelines; RCTs demonstrating improved outcomes with induction around 39 weeks of gestation
Consider recommending intensive lifestyle changes, administration of metformin, or both for patients with impaired glucose tolerance after a pregnancy complicated by GDM to reduce the risk of progression to type 2 diabetes. ⁷¹	C	RCT demonstrating reduction of progression to diabetes over 10 years with both metformin and lifestyle interventions

GDM = gestational diabetes mellitus; RCT = randomized controlled trial.

A = consistent, good-quality patient-oriented evidence; **B** = inconsistent or limited-quality patient-oriented evidence; **C** = consensus, disease-oriented evidence, usual practice, expert opinion, or case series. For information about the SORT evidence rating system, go to <https://www.aafp.org/afpsort>.

WHAT'S NEW ON THIS TOPIC

Gestational Diabetes Mellitus

As rates of inactivity, overweight/obesity, and advanced maternal age have increased, so has the incidence of GDM, which nearly doubled from 2006 to 2017.

A meta-analysis of four randomized controlled trials and 13 observational studies found no difference in large-for-gestational-age infants between one-step and two-step GDM screening methods, but patients screened with the one-step method experienced higher rates of hypoglycemia and infants admitted to the neonatal intensive care unit. The one-step method results in twice as many GDM diagnoses without improving neonatal or maternal outcomes.

A meta-analysis of 17 studies found that, compared with insulin, metformin leads to lower rates of macrosomia, neonatal hypoglycemia, neonatal intensive care unit admission, cesarean delivery, and pregnancy-induced hypertension in patients with GDM.

GDM = gestational diabetes mellitus.

delivery, birth injury, stillbirth, and admission to a neonatal intensive care unit.² Repeat screening during pregnancy is not generally recommended but may be warranted if a high-risk condition such as polyhydramnios develops.⁸ Recommended screening options include the one- and two-step methods, which are similarly effective.^{4,9}

The one-step method consists of a 75-g oral glucose tolerance test (OGTT) with glucose measurements after one and two hours. Diagnostic criteria for the 75-g OGTT are set by the International Association of Diabetes and Pregnancy Study Group; a positive result requires only one abnormal value.¹⁰

The two-step method consists of a 50-g OGTT with a glucose measurement after one hour. If the result is elevated, a diagnostic fasting 100-g OGTT is conducted, with glucose measurements each hour for three additional hours.^{4,10} For the initial 50-g OGTT, a positive result varies between 130 and 140 mg per dL (7.21 to 7.77 mmol per L), with institution-specific cutoffs.⁴ A threshold of 135 mg per dL (7.49 mmol per L) has 93% sensitivity and 79% specificity; this is similar to the specificity of the 140 mg per dL threshold (82%).² For patients with one-hour glucose values of greater than 199 mg per dL (11.04 mmol per L), forgoing

the confirmatory 100-g OGTT and presumptively treating for GDM can be considered.¹¹ The Carpenter-Coustan criteria or the National Diabetes Data Group threshold can be used to determine abnormal 100-g OGTT values. GDM is diagnosed if the measurement has two values at or above the chosen threshold, but even an elevation of one value may indicate increased risk of associated complications.⁴

Additionally, a meta-analysis of four randomized controlled trials and 13 observational studies found no difference in LGA infants between one-step and two-step methods, but patients screened with the one-step method experienced higher rates of hypoglycemia and infants admitted to the neonatal intensive care unit compared with those screened with the two-step method.¹² The one-step method results in twice as many GDM diagnoses as the two-step method and may be more cost-effective. However, it has not been shown to consistently improve neonatal or maternal outcomes despite being the approach most often used globally.^{2,12,13} Although either screening method is acceptable, the American College of Obstetricians and Gynecologists (ACOG) recommends the two-step method for screening at or after 24 weeks.⁴

Patients unable to tolerate oral glucose testing, including patients with a history of malabsorptive gastric bypass surgery, can be screened by recording a one- to two-week diary of fasting and postprandial capillary glucose levels.¹⁴ However, there is no standard threshold for establishing a diagnosis using glucose diary values.¹⁴

Thresholds for the different screening methods are summarized in Table 1.^{1,4,10,15}

The U.S. Preventive Services Task Force concludes that there is insufficient evidence to recommend universal testing for abnormal glucose tolerance in early pregnancy, but some patients may benefit from first-trimester screening.² Retrospective studies show that patients with preexisting diabetes and early-onset GDM have

higher rates of LGA infants, hypertensive disorders, cesarean delivery, and congenital malformations.^{2,16,17} A recent prospective study of more than 40,000 patients found that early screening and treatment of GDM in patients who are obese decrease the risk of LGA infants and cesarean delivery.¹⁸ ACOG and the American Diabetes Association (ADA) recommend considering screening high-risk patients early in pregnancy.^{1,4}

TABLE 1

Glucose Thresholds for Diagnosing Gestational Diabetes Mellitus After 24 Weeks of Gestation

Test method	Glucose threshold	
One-step method		
75-g OGTT	International Association of Diabetes and Pregnancy Study Group	
Fasting	92 mg per dL (5.11 mmol per L)	
One hour	180 mg per dL (9.99 mmol per L)	
Two hour	153 mg per dL (8.49 mmol per L)	
Two-step method		
50-g OGTT	Use institutional thresholds	
One hour	130 to 140 mg per dL (7.21 to 7.77 mmol per L)	
100-g OGTT	Carpenter-Coustan	National Diabetes Data Group
Fasting	95 mg per dL (5.27 mmol per L)	105 mg per dL (5.83 mmol per L)
One hour	180 mg per dL	190 mg per dL (10.54 mmol per L)
Two hour	155 mg per dL (8.6 mmol per L)	165 mg per dL (9.16 mmol per L)
Three hour	140 mg per dL	145 mg per dL (8.05 mmol per L)
Self-monitoring (if unable to perform OGTT)		
Fasting	95 mg per dL	
One hour postprandial	140 mg per dL	
Two hours postprandial	120 mg per dL (6.66 mmol per L)	

Note: For diagnosis of gestational diabetes, the 75-g OGTT requires only one abnormal result. The 100-g OGTT typically requires two abnormal results, although some physicians may choose to diagnose with only one abnormal value. For self-monitoring, there is no clear consensus regarding the number of abnormal values that constitutes a diagnosis of gestational diabetes.

OGTT = Oral glucose tolerance test.

Information from references 1, 4, 10, and 15.

GESTATIONAL DIABETES MELLITUS

Risk factors for early GDM include^{1,4}:

- Age 35 years or older
- BMI of 25 kg per m² or greater (23 kg per m² or greater in Asian people [studies show greater risk of adverse health outcomes at lower BMI in people of Asian ancestry; however, the reasons for this risk and variation among patients in Asian subgroups require further investigation¹⁹]); consider performing early glucose screening for patients with this risk factor and one or more additional risk factor
- BMI 40 kg per m² or greater; this risk factor alone may warrant testing
- First-degree relative with diabetes
- High-density lipoprotein cholesterol level less than 35 mg per dL (0.91 mmol per L) or triglyceride level greater than 250 mg per dL (2.82 mmol per L)
- History of cardiovascular disease, impaired fasting glucose (this single risk factor may warrant testing), delivering an infant with macrosomia (birth weight 4,000 g or greater), or GDM
- HIV
- Hypertension
- Inactivity
- Taking a medication associated with development of diabetes, such as atypical antipsychotics or corticosteroids
- Polycystic ovary syndrome
- Race/ethnicity such as Native American, African American, Latino, Asian American, Pacific Islander (causal factors for race and ethnicity as a risk factor are complex

and not fully understood and should not be assumed to be due to genetics alone)

- Signs of insulin resistance, such as acanthosis nigricans

The best screening test for abnormal glucose tolerance in early pregnancy is not clear. A1C level, fasting glucose level, or the one- or two-step method can be used⁴ (*Table 2*^{1,4,10,15,20-22,25}). Although the 2023 ADA guidelines recommend obtaining an A1C or fasting glucose measurement before 15 weeks of gestation to diagnose preexisting diabetes and impaired glucose tolerance, the biophysical changes of early pregnancy reduce the sensitivity to detect diabetes.^{1,23,24} A prospective randomized controlled trial of first-trimester testing to predict GDM found that compared with the two-step method or measurement of fasting plasma glucose, the one-step method has better sensitivity, specificity, and negative predictive value.²³ For patients with normal early glucose screening results, testing should be repeated between 24 and 28 weeks of gestation.^{1,4} An approach to GDM screening is presented in *Figure 1*.^{1,4,10,11,14,21}

Treatment

Initial treatment of GDM consists of glucose monitoring and targeted education on nutrition and exercise (*Figure 2*).^{4,25, 26, 28-30,39,43,50}

General dietary recommendations include a minimum daily intake of 175 g complex carbohydrates, which is approximately 35% of a 2,000-calorie diet.^{4,25} The ADA recommends individualized nutrition planning with a registered dietitian.²⁵ A Cochrane review found that no diet was clearly superior for GDM, but noted a reduction in cesarean

TABLE 2

Early Pregnancy Glucose Screening Thresholds

Test	Normal range	Impaired glucose tolerance/early GDM	Preexisting diabetes
A1C*	< 5.9%	5.9% to 6.4%	≥ 6.5%
Fasting plasma glucose	< 110 mg per dL (6.11 mmol per L)	110 to 125 mg per dL (6.11 to 6.94 mmol per L)	≥ 126 mg per dL (6.99 mmol per L)
75-g OGTT	Fasting plasma glucose: < 92 mg per dL (5.11 mmol per L) One hour: < 180 mg per dL (9.99 mmol per L) Two hour: < 153 mg per dL (8.49 mmol per L)	Fasting plasma glucose: 92 to 125 mg per dL (5.11 to 6.94 mmol per L) One hour: ≥ 180 mg per dL Two hour : ≥ 153 mg per dL	Fasting plasma glucose: ≥ 126 mg per dL

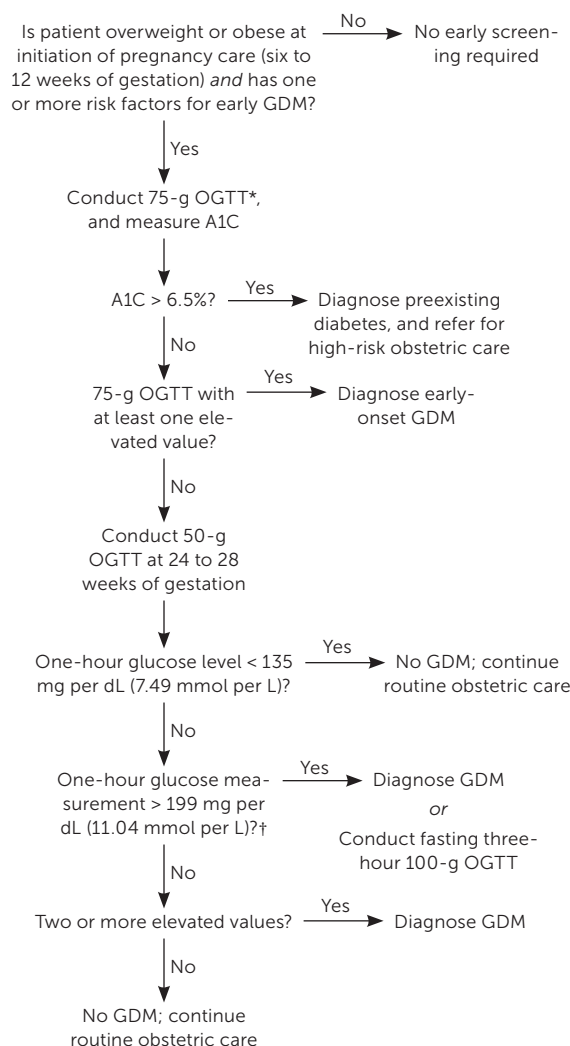
Note: The 100-g OGTT does not have separate parameters to differentiate between early GDM and preexisting diabetes; therefore, A1C is sometimes simultaneously obtained for this purpose.

GDM = gestational diabetes mellitus; OGTT = oral glucose tolerance test.

*—A1C is only valid before 15 weeks of gestation.

Information from references 1, 4, 10, 15, 20-22, and 25.

FIGURE 1



GDM = gestational diabetes mellitus; OGTT = oral glucose tolerance test.

*—Alternative method: 50-g OGTT followed by 100-g OGTT if positive.

†—One-hour OGTT value above 199 mg per dL has a 90% positive predictive value for GDM; consider the patient's preferences for further testing vs. presumptive diagnosis.

Screening for gestational diabetes mellitus.

Information from references 1, 4, 10, 11, 14, and 21.

FIGURE 2

At diagnosis of gestational diabetes mellitus:

Discuss diet, exercise, and weight management recommendations

Refer to registered dietitian if available

Recommend self-monitoring of glucose four times per day (fasting and one- or two-hour postprandial measurements)

Follow up in one to two weeks to review glucose values

Less than 20% of glucose values abnormal?

No

Discuss medication options with patient: insulin (recommended), metformin (acceptable alternative), glyburide (third-line option if necessary)

Yes

Continue lifestyle modifications
Review glucose log every two weeks to ensure progress

Insulin:

Start at up to 1 unit per kg in divided doses based on level of control

If glucose is poorly controlled, recommend:

- If only fasting glucose level is elevated, consider an individualized daily regimen with lower single doses, such as long-acting insulin

- Two-thirds daily dose before breakfast, comprising two-thirds intermediate-acting insulin and one-third short-acting insulin

- One-third daily dose in the evening, comprising one-half short-acting insulin given before dinner and one-half intermediate-acting before bedtime

- If short-acting insulin is regular insulin, patient should wait 30 minutes after dose before eating

- Follow up weekly

- Adjust by up to 10% of dose until less than 20% of glucose values are abnormal

Metformin:

Verify estimated glomerular filtration rate is 45 mL per minute per 1.73 m²

Start at 500 mg daily

Increase dose up to 3,000 mg daily (taken in divided doses) until less than 20% of glucose values are abnormal

Glyburide:

Start at 2.5 or 5 mg daily if glucose levels are poorly controlled

Follow up every three days to two weeks, depending on glucose control

Goal is to have less than 20% of glucose values above specification

Treatment of gestational diabetes mellitus.

Information from references 4, 25, 26, 28–30, 39, 43, and 50.

delivery rate with the DASH (Dietary Approaches to Stop Hypertension) diet in two trials with 86 patients.³¹

With GDM, exercise improves fasting and postprandial glucose control, but the effects on patient-centered outcomes are unknown.^{32–34} Combining diet and exercise interventions reduces the risk of LGA infants.^{34,35} Higher maternal age, BMI, and fasting blood glucose levels and earlier gestational age at diagnosis reduce the likelihood that glucose can be controlled by lifestyle modifications alone.³⁶

Daily glucose monitoring typically consists of measuring the fasting glucose value and three postprandial values, reviewed weekly. Consensus thresholds for hyperglycemia in pregnancy include more than 95 mg per dL (5.27 mmol

per L) fasting, more than 140 mg per dL one hour postprandial, and more than 120 mg per dL (6.66 mmol per L) two hours postprandial.^{4,25} There is no consensus regarding when pharmacotherapy is necessary to control glucose levels; recommended thresholds range from a single abnormal value to a week of 50% abnormal values.^{4,26,37} A reasonable approach is to start pharmacotherapy when more than 20% of glucose values are abnormal or when there are more than five abnormal values in seven days of careful monitoring. One small, retrospective study found that initiating pharmacotherapy when 20% to 40% of glucose measurements are abnormal improves neonatal outcomes compared with starting medications when 40% or more of glucose measurements are abnormal.²⁶

Measuring fetal growth via ultrasonography as an adjunct to glucose control does not appear to improve rates of neonatal hypoglycemia, cesarean delivery, shoulder dystocia, LGA infants, or overall neonatal morbidity.³⁸ Fetal echocardiography at 18 to 22 weeks of gestation should be considered for patients with early-onset GDM because the condition is associated with a higher risk of cardiac defects.^{39,40}

Glucose control cannot be achieved with lifestyle modifications alone in 30% of patients.²⁷ When pharmacologic management is needed, ACOG and the ADA primarily recommend insulin due to its long-standing safety profile, effectiveness, and inability to cross the placenta.^{4,25} The Society for Maternal-Fetal Medicine recommends considering metformin for its clinical effectiveness and cost, and if the patient prefers it.²⁷ Although previous meta-analyses suggested that use of metformin is equivalent to insulin in reducing rates of LGA infants, macrosomia, and neonatal hypoglycemia, recent studies suggest improved outcomes with metformin.⁴¹⁻⁴⁵ A 2021 meta-analysis of 17 studies found that, compared with insulin, metformin leads to lower rates of macrosomia (relative risk [RR] = 0.66; 95% CI, 0.50 to 0.88), neonatal hypoglycemia (RR = 0.67; 95% CI, 0.56 to 0.80), neonatal intensive care unit admission (RR = 0.78; 95% CI, 0.67 to 0.91), cesarean delivery (RR = 0.86; 95% CI, 0.50 to 0.90), and pregnancy-induced hypertension (RR = 0.47; 95% CI, 0.27 to 0.83).⁴⁴ Because metformin crosses the placenta, there is some concern about the long-term effects of in utero exposure. No difference in neurodevelopmental outcomes has been found in elementary school children exposed to metformin in utero.⁴⁶⁻⁴⁸ Systematic reviews demonstrate significantly increased weight in children exposed to metformin in utero, without a significant difference in BMI.^{46,49}

Glyburide can be considered for glucose control in patients who are unable or prefer not to take insulin or metformin.^{4,25} Like metformin, glyburide crosses the placenta, and the long-term developmental impact of in utero exposure is unknown. Although glyburide is equivalent to metformin for glucose control during pregnancy, it increases the risk of neonatal hypoglycemia and may increase the risk of preeclampsia, neonatal hyperbilirubinemia, and stillbirth.^{4,25,44,50}

Insulin is often prescribed in multiple divided doses of short-, intermediate-, and long-acting analogues. For those with only fasting hyperglycemia, single daily doses may be appropriate.⁴ A Cochrane review did not find any differences among various insulin types and dosage strategies.⁴³ Starting at 0.7 to 1 unit of insulin per kg per day should be considered for patients with persistent hyperglycemia.⁴ Asymptomatic hypoglycemia is uncommon in GDM; therefore, titrating the dose of insulin (up to 10% increments every two or three days) is reasonable with close patient follow-up.²⁸

Fetal Surveillance

The risk of stillbirth after 36 weeks of gestation is increased in patients with GDM to 17 per 10,000 births, compared with 13 per 10,000 births in patients without GDM.⁵¹ Antepartum fetal surveillance includes several noninvasive approaches to

TABLE 3

Examples of Antepartum Fetal Surveillance

Test	Description
Biophysical profile	20-minute fetal heart rate tracing plus ultrasonography, assigning points for fetal movement, tone, breathing, and single deepest vertical amniotic fluid pocket > 2 cm
Contraction stress test	10-minute fetal heart rate tracing with at least three contractions
Maternal-fetal movement assessment	Maternal perception of 10 fetal movements, up to two hours
Modified biophysical profile	Nonstress test and ultrasound identification of single deepest vertical amniotic fluid pocket > 2 cm
Nonstress test	20-minute fetal heart rate tracing
Umbilical artery doppler velocimetry	Ultrasonic assessment of vascular resistance typically used in growth-restricted fetuses

Note: Optimal frequency of testing is unknown; it is typically performed one or two times per week after 32 weeks of gestation.

Information from reference 52.

detect risk of stillbirth, with no specific testing strategy showing superiority (Table 3).⁵² Due to the increased rate of stillbirth, surveillance once or twice weekly beginning at 32 weeks of gestation is suggested for patients with poor glycemic control or who require medications.⁵³ The benefit of fetal surveillance for patients who manage GDM with lifestyle modifications is less clear. The Society for Maternal-Fetal Medicine has a Choosing Wisely recommendation against performing antepartum fetal surveillance in patients who have appropriate glucose control via dietary modifications alone unless additional indications arise.⁵⁴

Delivery for Patients With GDM

TYPE OF DELIVERY

ACOG recommends that physicians discuss the potential risks and benefits of prelabor cesarean delivery for patients with GDM when estimated fetal weight is more than 4,500 g.^{4,55} Patients with GDM are twice as likely to have a macrosomic fetus, increasing the risk of shoulder dystocia, brachial plexus injury, and cesarean delivery.⁵⁵ Ultrasound biometry is the main method for estimating fetal weight, but it has only a 56% sensitivity in predicting macrosomia.⁵⁶ Serial ultrasound growth measurements are often performed but may not improve sensitivity in predicting fetal macrosomia compared with a single study performed in the late third trimester.⁵⁷ The limited accuracy of estimated fetal weight in predicting brachial plexus injury means that more than 500 cesarean deliveries may be needed to prevent one case of permanent fetal neurologic insult.⁵⁸

DELIVERY TIMING

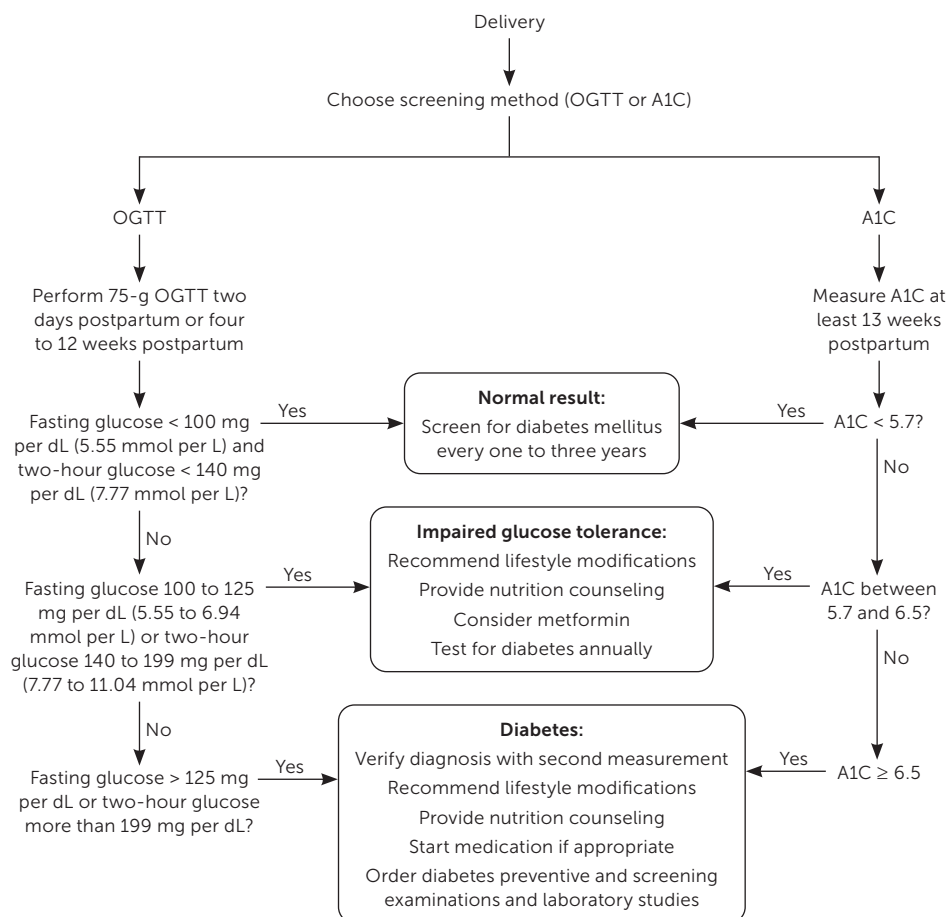
Delivery for patients with well-managed GDM is not recommended before 39 weeks of gestation.⁴ A large, retrospective study showed that induction of labor before 40 weeks

of gestation in patients with GDM decreases rates of cesarean delivery and hypertensive disorders.⁵⁹ Induction before 39 weeks of gestation reduces rates of shoulder dystocia but increases rates of neonatal hypoglycemia, hyperbilirubinemia, and neonatal intensive care unit admission.⁵⁹ Several small trials demonstrate that induction before 39 weeks of gestation increases neonatal morbidity.^{60,61} If glucose control remains poor despite medications, delivery prior to 39 weeks may be considered in consultation with specialists.^{4,62} ACOG recommends delivery in the 39th or 40th week of gestation for patients with diet-controlled GDM and during the 39th week of gestation for patients with medication-controlled GDM.⁶²

INTRAPARTUM MANAGEMENT

Intrapartum management of GDM is largely extrapolated from data on patients with preexisting diabetes, which suggests that glucose levels should be maintained between

FIGURE 3



OGTT = oral glucose tolerance test.

Postpartum follow-up for gestational diabetes mellitus.

Information from references 2, 4, 25, and 71.

70 and 110 mg per dL (3.89 to 6.11 mmol per L).^{25,30} Patients with diet-controlled GDM may be less likely to develop hyperglycemia in labor, but evidence is lacking.⁶³ A retrospective study of 3,680 infants of mothers with GDM or type 1 or 2 diabetes demonstrated no association between maternal intrapartum glucose levels and neonatal hypoglycemia after adjusting for neonatal size, gestational age, and sex.⁶⁴ Additional studies have found inconsistent improvement in fetal hypoglycemia with intrapartum maternal glucose control, suggesting intrapartum maternal glucose may play a smaller role in immediate neonatal glucose control than previously thought.⁶⁵⁻⁶⁷

Depending on the planned time of induction, patients taking insulin can reduce or discontinue their morning dose.³⁰ Maternal glucose monitoring is typically checked hourly during active labor, but one study showed similar rates of neonatal hypoglycemia with measurement once every four hours.⁶⁸ Glucose control can be achieved with continuous administration of insulin, rotating fluids with dextrose and insulin, or with protocols that include administration of insulin on a sliding scale.⁶⁷⁻⁶⁹

Postpartum

Following delivery, maternal glucose levels typically return to prepregnancy values. However, the risk of developing overt diabetes within 25 years is 10 times higher in patients who have a history of GDM compared with those who do not.⁷⁰ ACOG and the ADA recommend a two-hour OGTT performed four to 12 weeks postpartum to screen for persistently abnormal glucose control (*Figure 3*^{2,4,25,71}). Only 35% of patients complete this testing due to barriers such as lack of knowledge of guidelines, provider-to-provider and provider-to-patient communication errors, lack of insurance coverage, and not being present for postpartum follow-up.^{4,25,72}

Alternative postpartum screening methods include a two-hour 75-g OGTT on the second day postpartum, a fasting glucose assessment before 13 weeks postpartum, and an A1C measurement at least 13 weeks postpartum.⁷³⁻⁷⁶ The two-hour OGTT and A1C measurement are as reliable at predicting diabetes at one year postpartum as the two-hour OGTT performed at four and 12 weeks.^{72,73,77} A prospective cohort study of 300 patients found that a 75-g OGTT performed on the second day postpartum is as accurate at detecting diabetes or impaired glucose tolerance as testing at four to 12 weeks.⁷⁴

Breastfeeding may protect against future development of diabetes and should be encouraged.^{77,78} A meta-analysis of 17 studies found that patients with a history of GDM who do not breastfeed have higher blood glucose levels and a greater risk of developing type 2 diabetes compared with those who do breastfeed.⁷⁸

For patients with postpartum impaired glucose tolerance, treatment can reduce progression to type 2 diabetes. Intensive lifestyle modifications reduce the risk of diabetes over 10 years, with a number needed to treat of 12 compared with placebo. Metformin is more effective in preventing progression to diabetes, with a number needed to treat of 8 over 10 years compared with placebo.⁷¹ Due to the high lifetime risk of GDM, patients with normal postpartum test results should have follow-up testing performed at least every one to three years.^{4,25}

This article updates a previous article on this topic by Garrison.⁷⁹

Data Sources: A PubMed search was completed using the term gestational diabetes. The search included meta-analyses, randomized controlled trials, reviews, and guidelines. The Cochrane database, ACOG, DynaMed, and UpToDate were also searched. Whenever possible, studies using race as a primary factor that did not define how these categories were assigned were excluded from the final review. Search dates: April 30 to September 23, 2022; December 7, 2022; January 13, 2023, and July 24, 2023.

The opinions and assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Uniformed Services University of the Health Sciences, U.S. Army, the U.S. Department of Defense, or the U.S. government.

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References

1. ElSayed NA, Aleppo G, Arora VR, et al.; American Diabetes Association. Classification and diagnosis of diabetes: standards of care in diabetes-2023 [published correction appears in *Diabetes Care*. 2023;46(5):1106]. *Diabetes Care*. 2023;46(suppl 1):S19-S40.
2. Pillay J, Donovan L, Guitard S, et al. Screening for gestational diabetes: updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2021;326(6):539-562.
3. Zhou T, Du S, Sun D, et al. Prevalence and trends in gestational diabetes mellitus among women in the United States, 2006-2017: a population-based study. *Front Endocrinol (Lausanne)*. 2022;13:868094.
4. ACOG practice bulletin no. 190: gestational diabetes mellitus. *Obstet Gynecol*. 2018;131(2):e49-e64.

5. Black KI, Schneuer F, Gordon A, et al. Estimating the impact of change in pre-pregnancy body mass index on development of gestational diabetes mellitus: an Australian population-based cohort. *Women Birth*. 2022;35(6):563-569.
6. American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Obstetrics. Obesity in pregnancy: ACOG practice bulletin, number 230. *Obstet Gynecol*. 2021;137(6):e128-e144.
7. Griffith RJ, Alsweiler J, Moore AE, et al. Interventions to prevent women from developing gestational diabetes mellitus: an overview of Cochrane Reviews. *Cochrane Database Syst Rev*. 2020;(6):CD012394.
8. Dashe JS, Pressman EK, Hibbard JU; Society for Maternal-Fetal Medicine. SMFM consult series #46: evaluation and management of polyhydramnios. *Am J Obstet Gynecol*. 2018;219(4):B2-B8.
9. Farrar D, Duley L, Dowswell T, et al. Different strategies for diagnosing gestational diabetes to improve maternal and infant health. *Cochrane Database Syst Rev*. 2017;(8):CD007122.
10. Metzger BE, Gabbe SG, Persson B, et al. International Association of Diabetes and Pregnancy Study Groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. *Diabetes Care*. 2010;33(3):676-682.
11. Bobrowski RA, Bottoms SF, Micallef JA, et al. Is the 50-gram glucose screening test ever diagnostic? *J Matern Fetal Med*. 1996;5(6):317-320.
12. Brady M, Hensel DM, Paul R, et al. One-step compared with two-step gestational diabetes screening and pregnancy outcomes: a systematic review and meta-analysis. *Obstet Gynecol*. 2022;140(5):712-723.
13. Saccone G, Khalifeh A, Al-Kouatly HB, et al. Screening for gestational diabetes mellitus: one step versus two step approach. A meta-analysis of randomized trials. *J Matern Fetal Neonatal Med*. 2020;33(9):1616-1624.
14. ACOG practice bulletin no. 105: bariatric surgery and pregnancy. *Obstet Gynecol*. 2009;113(6):1405-1413.
15. Benhalima K, Minschart C, Ceulemans D, et al. Screening and Management of Gestational Diabetes Mellitus after Bariatric Surgery. *Nutrients*. 2018;10(10):1479. Published 2018 Oct 11. doi:10.3390/nu10101479
16. Immanuel J, Simmons D. Screening and treatment for early-onset gestational diabetes mellitus: a systematic review and meta-analysis. *Curr Diab Rep*. 2017;17(11):115.
17. Gupta S, Dolin C, Jadhav A, et al. Obstetrical outcomes in patients with early onset gestational diabetes. *J Matern Fetal Neonatal Med*. 2016; 29(1):27-31.
18. Hillier TA, Pedula KL, Ogasawara KK, et al. Impact of earlier gestational diabetes screening for pregnant people with obesity on maternal and perinatal outcomes. *J Perinat Med*. 2022;50(8):1036-1044.
19. Shah NS, Luncheon C, Kandula NR, et al. Heterogeneity in obesity prevalence among Asian American adults. *Ann Intern Med*. 2022;175(11):1493-1500.
20. Bhattacharya S, Nagendra L, Krishnamurthy A, et al. Early gestational diabetes mellitus: diagnostic strategies and clinical implications. *Med Sci (Basel)*. 2021;9(4):59.
21. Zaccara TA, Paganoti CF, Mikami FCF, et al. Early vs. late gestational diabetes: comparison between two groups diagnosed by abnormal initial fasting plasma glucose or mid-pregnancy oral glucose tolerance test. *Int J Environ Res Public Health*. 2022;19(21):13719.
22. Boe B, Barbour LA, Allshouse AA, et al. Universal early pregnancy glycosylated hemoglobin A1c as an adjunct to Carpenter-Coustan screening: an observational cohort study. *Am J Obstet Gynecol MFM*. 2019; 1(1):24-32.
23. Yeral MI, Ozgu-Erdinc AS, Uyur D, et al. Prediction of gestational diabetes mellitus in the first trimester, comparison of fasting plasma glucose, two-step and one-step methods: a prospective randomized controlled trial. *Endocrine*. 2014;46(3):512-518.
24. González-González NL, González-Dávila E, Megía A, et al. The NDDG criteria versus the IADPSG or the ADA criteria for diagnosing early-onset gestational diabetes mellitus or abnormal glucose tolerance. *Int J Gynaecol Obstet*. 2023;160(3):906-914.
25. ElSayed NA, Aleppo G, Aroda VR, et al.; American Diabetes Association. 15. Management of diabetes in pregnancy: standards of care in diabetes-2023. *Diabetes Care*. 2023;46(suppl 1):S254-S266.
26. Harrison RK, Cruz M, Wong A, et al. The timing of initiation of pharmacotherapy for women with gestational diabetes mellitus. *BMC Pregnancy Childbirth*. 2020;20(1):773.
27. Society of Maternal-Fetal Medicine Publications Committee. SMFM statement: pharmacological treatment of gestational diabetes. *Am J Obstet Gynecol*. 2018;218(5):B2-B4.
28. Blum AK. Insulin use in pregnancy: an update [published correction appears in *Diabetes Spectr*. August 2016;29(3):191]. *Diabetes Spectr*. 2016;29(2):92-97.
29. Gestational diabetes: calculation of caloric requirements and initial insulin dose. Accessed September 9, 2022. <https://perinatology.com/calculators/GDM.htm>
30. American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Obstetrics. ACOG practice bulletin no. 201: pregestational diabetes mellitus. *Obstet Gynecol*. 2018;132(6):e228-e248.
31. Han S, Middleton P, Shepherd E, et al. Different types of dietary advice for women with gestational diabetes mellitus. *Cochrane Database Syst Rev*. 2017;(2):CD009275.
32. Dingena CF, Arofikina D, Campbell MD, et al. Nutritional and exercise-focused lifestyle interventions and glycemic control in women with diabetes in pregnancy: a systematic review and meta-analysis of randomized clinical trials. *Nutrients*. 2023;15(2):323.
33. Laredo-Aguilera JA, Gallardo-Bravo M, Rabanales-Sotos JA, et al. Physical activity programs during pregnancy are effective for the control of gestational diabetes mellitus. *Int J Environ Res Public Health*. 2020; 17(17):6151.
34. Brown J, Alwan NA, West J, et al. Lifestyle interventions for the treatment of women with gestational diabetes. *Cochrane Database Syst Rev*. 2017;(5):CD011970.
35. Martis R, Crowther CA, Shepherd E, et al. Treatments for women with gestational diabetes mellitus: an overview of Cochrane systematic reviews. *Cochrane Database Syst Rev*. 2018;(8):CD012327.
36. Krispin E, Ashkenazi Katz A, Shmuel E, et al. Characterization of women with gestational diabetes who failed to achieve glycemic control by lifestyle modifications. *Arch Gynecol Obstet*. 2021;303(3):677-683.
37. Caissutti C, Saccone G, Khalifeh A, et al. Which criteria should be used for starting pharmacologic therapy for management of gestational diabetes in pregnancy? Evidence from randomized controlled trials. *J Matern Fetal Neonatal Med*. 2019;32(17):2905-2914.
38. Rao U, de Vries B, Ross GP, et al. Fetal biometry for guiding the medical management of women with gestational diabetes mellitus for improving maternal and perinatal health. *Cochrane Database Syst Rev*. 2019; (9):CD012544.
39. Donofrio MT, Moon-Grady AJ, Hornberger LK, et al. Diagnosis and treatment of fetal cardiac disease: a scientific statement from the American Heart Association [published correction appears in *Circulation*. 2014;129(21):e512]. *Circulation*. 2014;129(21):2183-2242.
40. AIUM practice parameter for the performance of fetal echocardiography. *J Ultrasound Med*. 2020;39(1):E5-E16.
41. Musa OAH, Syed A, Mohamed AM, et al. Metformin is comparable to insulin for pharmacotherapy in gestational diabetes mellitus: a network meta-analysis evaluating 6046 women. *Pharmacol Res*. 2021;167: 105546.
42. Farrar D, Simmonds M, Bryant M, et al. Treatments for gestational diabetes: a systematic review and meta-analysis. *BMJ Open*. 2017;7(6): e015557.
43. Brown J, Grzeskowiak L, Williamson K, et al. Insulin for the treatment of women with gestational diabetes. *Cochrane Database Syst Rev*. 2017; (11):CD012037.
44. Wang X, Liu W, Chen Q, et al. Comparison of insulin, metformin, and glyburide on perinatal complications of gestational diabetes mellitus:

- a systematic review and meta-analysis. *Gynecol Obstet Invest.* 2021;86(3):218-230.
45. Sheng B, Ni J, Lv B, et al. Short-term neonatal outcomes in women with gestational diabetes treated using metformin versus insulin: a systematic review and meta-analysis of randomized controlled trials. *Acta Diabetol.* 2023;60(5):595-608.
46. Xu Q, Xie Q. Long-term effects of prenatal exposure to metformin on the health of children based on follow-up studies of randomized controlled trials: a systematic review and meta-analysis. *Arch Gynecol Obstet.* 2019;299(5):1295-1303.
47. Greger HK, Hanem LGE, Østgård HF, et al. Cognitive function in metformin exposed children, born to mothers with PCOS - follow-up of an RCT. *BMC Pediatr.* 2020;20(1):60.
48. Tertti K, Eskola E, Rönnemaa T, et al. Neurodevelopment of two-year-old children exposed to metformin and insulin in gestational diabetes mellitus. *J Dev Behav Pediatr.* 2015;36(9):752-757.
49. van Weelden W, Wekker V, de Wit L, et al. Long-term effects of oral anti-diabetic drugs during pregnancy on offspring: a systematic review and meta-analysis of follow-up studies of RCTs. *Diabetes Ther.* 2018;9(5):1811-1829.
50. Brown J, Martis R, Hughes B, et al. Oral anti-diabetic pharmacological therapies for the treatment of women with gestational diabetes. *Cochrane Database Syst Rev.* 2017;(1):CD011967.
51. Rosenstein MG, Cheng YW, Snowden JM, et al. The risk of stillbirth and infant death stratified by gestational age in women with gestational diabetes. *Am J Obstet Gynecol.* 2012;206(4):309.e1-309.e7.
52. American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Obstetrics. Antepartum fetal surveillance: ACOG practice bulletin, number 229. *Obstet Gynecol.* 2021;137(6):e116-e127.
53. American College of Obstetricians and Gynecologists' Committee on Obstetric Practice, Society for Maternal-Fetal Medicine. Indications for outpatient antenatal fetal surveillance: ACOG committee opinion, number 828. *Obstet Gynecol.* 2021;137(6):e177-e197.
54. Society for Maternal-Fetal Medicine. Choosing Wisely: twenty things physicians and patients should question. March 10, 2021. Accessed September 26, 2022. <https://www.smfm.org/publications/378-choosing-wisely-twenty-things-physicians-and-patients-should-question>
55. Macrosomia: ACOG practice bulletin, number 216. *Obstet Gynecol.* 2020;135(1):e18-e35.
56. Malin GL, Bugg GJ, Takwoingi Y, et al. Antenatal magnetic resonance imaging versus ultrasound for predicting neonatal macrosomia: a systematic review and meta-analysis. *BJOG.* 2016;123(1):77-88.
57. Zhang J, Kim S, Grewal J, et al. Predicting large fetuses at birth: do multiple ultrasound examinations and longitudinal statistical modelling improve prediction? *Paediatr Perinat Epidemiol.* 2012;26(3):199-207.
58. Garabedian C, Deruelle P. Delivery (timing, route, peripartum glycemic control) in women with gestational diabetes mellitus. *Diabetes Metab.* 2010;36(6 pt 2):515-521.
59. Melamed N, Ray JG, Geary M, et al. Induction of labor before 40 weeks is associated with lower rate of cesarean delivery in women with gestational diabetes mellitus. *Am J Obstet Gynecol.* 2016;214(3):364.e1-364.e8.
60. Worda K, Bancher-Todesca D, Husslein P, et al. Randomized controlled trial of induction at 38 weeks versus 40 weeks gestation on maternal and infant outcomes in women with insulin-controlled gestational diabetes. *Wien Klin Wochenschr.* 2017;129(17-18):618-624.
61. Alberico S, Erenbourg A, Hod M, et al. Immediate delivery or expectant management in gestational diabetes at term: the GINEXMAL randomised controlled trial. *BJOG.* 2017;124(4):669-677.
62. American College of Obstetricians and Gynecologists' Committee on Obstetric Practice, Society for Maternal-Fetal Medicine. Medically indicated late-preterm and early-term deliveries: ACOG committee opinion, number 831. *Obstet Gynecol.* 2021;138(1):e35-e39.
63. Barrett HL, Morris J, McElduff A. Watchful waiting: a management protocol for maternal glycaemia in the peripartum period. *Aust N Z J Obstet Gynaecol.* 2009;49(2):162-167.
64. Yamamoto JM, Donovan LE, Mohammad K, et al. Severe neonatal hypoglycaemia and intrapartum glycaemic control in pregnancies complicated by type 1, type 2 and gestational diabetes. *Diabet Med.* 2020;37(1):138-146.
65. Yamamoto JM, Benham J, Mohammad K, et al. Intrapartum glycaemic control and neonatal hypoglycaemia in pregnancies complicated by diabetes: a systematic review. *Diabet Med.* 2018;35(2):173-183.
66. Anwer TZ, Aguayo R, Modest AM, et al. Reexamining intrapartum glucose control in patients with diabetes and risk of neonatal hypoglycemia. *J Perinatol.* 2021;41(12):2754-2760.
67. Dude AM, Niznik C, Peaceman AM, et al. Evaluation of an intrapartum insulin regimen for women with diabetes. *Obstet Gynecol.* 2020;136(2):411-416.
68. Hamel MS, Kanno LM, Has P, et al. Intrapartum glucose management in women with gestational diabetes mellitus: a randomized controlled trial. *Obstet Gynecol.* 2019;133(6):1171-1177.
69. Rosenberg VA, Eglinton GS, Rauch ER, et al. Intrapartum maternal glycemic control in women with insulin requiring diabetes: a randomized clinical trial of rotating fluids versus insulin drip. *Am J Obstet Gynecol.* 2006;195(4):1095-1099.
70. Vounzoulaki E, Khunti K, Abner SC, et al. Progression to type 2 diabetes in women with a known history of gestational diabetes: systematic review and meta-analysis. *BMJ.* 2020;369:m1361.
71. 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(4):1646-1653.
72. Battarbee AN, Yee LM. Barriers to postpartum follow-up and glucose tolerance testing in women with gestational diabetes mellitus. *Am J Perinatol.* 2018;35(4):354-360.
73. Carson MP, Ananth CV, Gyamfi-Bannerman C, et al. Postpartum testing to detect persistent dysglycemia in women with gestational diabetes mellitus. *Obstet Gynecol.* 2018;132(1):193-198.
74. Werner EF, Has P, Tarabulsi G, et al. Early postpartum glucose testing in women with gestational diabetes mellitus [published correction appears in *Am J Perinatol.* 2016;33(14):1433-1434]. *Am J Perinatol.* 2016;33(10):966-971.
75. Werner EF, Has P, Rouse D, et al.; Society for Maternal-Fetal Medicine (SMFM). Two-day postpartum compared with 4- to 12-week postpartum glucose tolerance testing for women with gestational diabetes. *Am J Obstet Gynecol.* 2020;223(3):439.e1-439.e7.
76. Dinglas C, Muscat J, Heo H, et al. Immediate postpartum glucose tolerance testing in women with gestational diabetes: a pilot study. *Am J Perinatol.* 2017;34(12):1264-1270.
77. Eastman LM, de Los Reyes S, Dude A. The association of immediate postpartum glucose values with persistent insulin resistance in patients with gestational diabetes. *Am J Obstet Gynecol MFM.* 2022;4(2):100526.
78. Pathirana MM, Ali A, Lassi ZS, et al. Protective influence of breastfeeding on cardiovascular risk factors in women with previous gestational diabetes mellitus and their children: a systematic review and meta-analysis. *J Hum Lact.* 2022;38(3):501-512.
79. Garrison A. Screening, diagnosis, and management of gestational diabetes mellitus. *Am Fam Physician.* 2015;91(7):460-467.