Preexisting (pregestational) and gestational diabetes: Intrapartum and postpartum glucose management

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INTRODUCTION

In pregnancies complicated by diabetes, a key therapeutic goal across gestation is avoidance of maternal hyperglycemia, which increases the risk of adverse pregnancy outcomes, including preeclampsia, fetal macrosomia, and neonatal hypoglycemia, among others. Strict avoidance of hyperglycemia remains important during labor because maternal hyperglycemia at that time has been linked to fetal hypoxemia and neonatal hypoglycemia. Glycemic targets are relaxed postpartum both because the fetus is no longer exposed to maternal hyperglycemia and because the risk for maternal hypoglycemia increases when insulin resistance dramatically falls after placental expulsion.

This topic will discuss inpatient glycemic management in preexisting (also called pregestational) and gestational diabetes, with a focus on the intrapartum and postpartum periods. Other issues in the management of diabetes in pregnancy are reviewed separately:

- (See "Preexisting (pregestational) diabetes: Preconception counseling, evaluation, and management".)
- (See "Preexisting (pregestational) diabetes mellitus: Antenatal glycemic management".)
- (See "Preexisting (pregestational) diabetes mellitus: Obstetric issues and pregnancy management".)
- (See "Diabetic ketoacidosis in pregnancy".)
- (See "Gestational diabetes mellitus: Glucose management, maternal prognosis, and follow-up".)
- (See "Gestational diabetes mellitus: Obstetric issues and management".)

INTRAPARTUM MANAGEMENT

Factors affecting glycemic management — Intensive management of maternal glycemia during labor and delivery is commonly recommended to optimize fetal outcomes. During labor, a variety of factors impact glycemic management and should be considered:

- **Metabolic demands of labor** – During the active phase of labor, glucose uptake by the contracting uterus lowers blood glucose and reduces insulin requirements, analogous to exercise (see "Exercise guidance in adults with diabetes mellitus").

- **Food restriction** – Many people in labor are placed on a clear liquid diet. Caloric restriction can reduce insulin requirements, but clear liquid diets that include sugar-sweetened beverages can cause hyperglycemia (see "Labor and delivery: Management of the normal first stage", section on 'Oral intake').

- **Dextrose-containing intravenous fluids** – Administration of dextrose-containing fluids may prevent dehydration, shorten the length of labor, and prevent ketosis, but may also lead to hyperglycemia if insulin is not present in sufficient quantities (see "Labor and delivery: Management of the normal first stage", section on 'Intravenous fluids').

Glycemic targets — A reasonable target range for intrapartum glucose levels is **70 to 125 mg/dL (3.9 to 6.9 mmol/L)**. This target range encompasses recommendations of the American College of Obstetricians and Gynecologists (ACOG; 70 to 110 mg/dL [3.9 to 6.1 mmol/L]) [1].

Rationale — Attention to intrapartum avoidance of hyperglycemia is based on evidence that it reduces the risk of two major complications: fetal hypoxemia and neonatal hypoglycemia.

- **Fetal hypoxemia** — Most of the literature relating fetal hypoxemia to maternal hyperglycemia was published prior to 1990, before the availability of rapid-acting insulin analogues and the publication of seminal studies demonstrating the benefits of intensive glycemic control in diabetes [2]; yet, this literature provides strong evidence for a causal relationship between maternal hyperglycemia and fetal hypoxemia during labor. For example:

  - Experimental studies in sheep suggest that fetal hyperglycemia and hyperinsulinemia (resulting from maternal hyperglycemia) increase fetal oxygen consumption and can lead to fetal hypoxemia, acidemia, and (if severe enough) death [3,4].

  - In pregnant individuals without diabetes, rapid infusion of 50 grams of dextrose during labor (as compared with lactated ringers or normal saline) resulted in maternal

and fetal hyperglycemia and reduced cord blood pH in a randomized trial [5].

- In pregnant individuals with diabetes, an observational study found that glycemic control in the six hours prior to giving birth was associated with perinatal asphyxia (defined as late decelerations, prolonged fetal bradycardia, one-minute APGAR <6, or intrauterine fetal death), while maternal glycated hemoglobin (A1C) in the third trimester was not [6]. Participants in this study with and without perinatal asphyxia had a mean blood glucose during labor of 161 mg/dL (8.9 mmol/L) and 127 mg/dL (7.1 mmol/L), respectively; average A1C at 36 weeks of gestation was 8.5 and 8.0 percent.

- Theoretically, if intrapartum hyperglycemia occurs on a background of chronic maternal hyperglycemia (high A1C), which reduces red blood cell 2.3-diphosphoglycerate (2,3-DPG) concentrations, then maternal hemoglobin will bind oxygen more tightly and therefore release it less well in areas of low oxygen tension, such as the intervillous space [7,8]. This could compound intrapartum fetal hypoxemia and acidemia [6].

- **Neonatal hypoglycemia** — Maternal hyperglycemia causes fetal hyperinsulinemia, which can result in hypoglycemia after birth [9-11]. Neonatal hypoglycemia is usually transient, but neurologic sequelae can occur and neonatal intensive care unit (NICU) admission may be needed. (See "Management and outcome of neonatal hypoglycemia".)

  Whether antenatal or intrapartum glucose control is more important for reducing the risk of neonatal hypoglycemia is uncertain. Antenatal hyperglycemia may result in chronic fetal hyperinsulinemia, while intrapartum hyperglycemia may result in acute fetal hyperinsulinemia, both of which may persist temporarily after birth in newborns.

  - In a 2002 study of 107 individuals with type 1 diabetes, mean intrapartum glucose levels >140 mg/dL (7.8 mmol/L) resulted in hypoglycemia in over 80 percent of neonates, while A1C levels from the first, second, and third trimester were not associated with neonatal blood glucose [10].

  - However, a 2018 systematic review found that results of studies evaluating the association between intrapartum glucose levels and neonatal hypoglycemia were mixed; many studies reporting a relationship were older (ie, not reflecting contemporary management for diabetes in pregnancy) and failed to account for confounders such as antenatal glycemic control, preterm birth, and large for gestational age birth weight [11].

  - In a 2020 observational study that adjusted for these factors (157 type 1 diabetes, 237 type 2 diabetes, 3256 gestational diabetes), intrapartum glycemic control was not significantly associated with neonatal hypoglycemia [12].

- A 2019 secondary analysis of the CONCEPTT randomized trial of continuous glucose monitoring (CGM) during pregnancy also found that intrapartum glucose levels (available in only 33 participants) were not associated with neonatal hypoglycemia [13]. In this small study, antenatal glycemia (by CGM and A1C) and fetal/neonatal markers of chronic exposure to maternal hyperglycemia were stronger correlates of neonatal hypoglycemia.

Glucose monitoring — The optimum method and frequency of glucose monitoring have not been established. We measure capillary glucose levels and determine the frequency based on a combination of factors, including the phase of labor, whether food is restricted, and the insulin regimen.

- **Latent phase capillary glucose monitoring**

  - **Food not restricted** – During the latent phase, if the patient is eating, we generally continue the standard glucose monitoring schedule that was used antenatally: capillary glucose monitoring fasting and one to two hours after meals. If prandial insulin has been required, we also check capillary blood glucose prior to meals.

  - **Food restricted** – Once food is restricted, we measure capillary glucose levels every four hours and administer insulin as needed to maintain euglycemia (see 'Insulin management' below).

- **Active phase capillary glucose monitoring** (food is typically restricted during this phase)

  - During the active phase, we monitor capillary blood glucose every hour in patients on an intravenous insulin infusion or an insulin pump; this includes all patients with type 1 diabetes.

  - In patients on subcutaneous insulin or on no insulin during labor, we measure capillary blood glucose every two to four hours, depending on the stability of the blood glucose levels. In a randomized trial of strict versus liberal intrapartum glycemic management for gestational diabetes, monitoring and treating capillary blood glucose with correctional insulin every four hours as compared with hourly did not result in a greater risk of neonatal hypoglycemia [14]. In fact, neonatal blood glucose in the first 24 hours of life was lower in the group that had hourly monitoring and a stricter glucose target (60 to 100 mg/dL [3.3 to 5.6 mmol/L] versus 60 to 120 mg/dL [3.3 to 6.7 mmol/L]).

- **Continuous glucose monitoring (CGM) devices** – An increasing number of people with diabetes are using CGM devices throughout pregnancy. There is limited evidence supporting the accuracy of these devices in the inpatient setting, though hospital use increased during the COVID-19 pandemic. (See "COVID-19: Issues related to diabetes mellitus in adults".) In a single study that compared glucose measured by intermittently

scanned CGM and capillary blood glucose using a hospital point-of-care glucometer in patients undergoing cesarean birth, the mean absolute relative difference of paired glucose measurements (a measure of accuracy) was similar to that reported in studies in pregnant and nonpregnant individuals in the outpatient setting [15]. Sixty-eight percent of glucose values were "concordant" (ie, they would have resulted in the same intrapartum glycemic management) and the discordant glucose values only occurred when the glucose was <70 mg/dL (3.9 mmol/L) or >110 mg/dL (6.1 mmol/L).

Most hospitals require confirmation of CGM glucose readings via capillary blood glucose monitoring for insulin dosing decisions. It is our practice to perform capillary blood glucose monitoring at the frequencies described above even if patients continue to use their home CGM devices as an adjunct for self-management. CGM sensors should be worn at a site away from the lower abdomen (eg, flank or upper arm). Discrepancies between capillary glucose measurements and CGM measurements should be noted and addressed with calibration if available on the CGM device being used. (See "Glucose monitoring in the ambulatory management of nonpregnant adults with diabetes mellitus", section on 'CGM systems'.)

Insulin management — We individualize insulin management during labor, considering the type of diabetes, regimen prior to labor, and glucose level on presentation. The following approaches should not be considered absolute protocols and may need to be adjusted to meet changing intrapartum needs.

Type 1 diabetes — People with type 1 diabetes have minimal to no endogenous insulin production and require exogenous basal insulin without interruption to prevent diabetic ketoacidosis. Euglycemia should not preclude the administration of basal insulin. Additional insulin is required for any carbohydrate intake. A review of these principles can be found elsewhere. (See "Management of blood glucose in adults with type 1 diabetes mellitus".)

In the active phase of labor, patients with type 1 diabetes may have a considerable drop in insulin requirements, and often require dextrose infusion to allow continued and necessary insulin administration [16].

Patients on multiple daily insulin injections

- **Before food is restricted**, patients with type 1 diabetes need basal, preprandial, and correctional insulin. We typically provide preprandial and correctional coverage using the home subcutaneous insulin regimen. If the patient's blood glucose levels have been tightly controlled at home or if the patient is not eating full meals on the labor unit, a dose reduction of 20 to 30 percent may be necessary to prevent hypoglycemia.

- **After food is restricted** – As the patient enters active labor or when food becomes restricted, we administer dextrose-containing intravenous fluids (5 or 10 percent dextrose) and start an insulin infusion using a standardized protocol, such as that published by Dude et al [17]. Patients who present with significant hyperglycemia (eg, >200 mg/dL [11.1 mmol/L]) may have an insulin infusion initiated in early labor, rather than waiting until active labor. Use of an insulin infusion for intrapartum glycemic management is recommended by ACOG [1].

  In patients starting insulin infusions, we hold dextrose-containing fluids if the blood glucose prior to starting the insulin infusion is ≥160 mg/dL (8.9 mmol/L), to bring blood glucose into the target range (70 to 125 mg/dL [3.9 to 6.9 mmol/L]) more rapidly. After the blood glucose declines below 160 mg/dL (8.9 mmol/L), the dextrose-containing fluids can be started and continued, with further hyperglycemia managed using a change in the rate of the insulin infusion, per protocol. A small dose of basal insulin (equivalent to the postpartum insulin dose) can be given in addition to the insulin infusion protocol to prevent inadvertent interruptions to basal insulin delivery in type 1 diabetes.

- **Protocols** – Various reasonable protocols for intrapartum intravenous insulin are available [1,17-20]. Two studies of specific protocols have reported excellent maternal glycemic outcomes:

  - A pre-post implementation study by Dude et al evaluated an intrapartum management protocol for laboring patients that accounted for an individual patient's antenatal insulin requirement (a proxy for insulin resistance) [18]. As compared with nonprotocolized management prior to protocol implementation, this protocol was associated with lower peak maternal intrapartum glucose (127 mg/dL pre versus 116 mg/dL post), reduced maternal hyperglycemia (>125 mg/dL [6.9 mmol/L], 51 percent pre versus 38 percent post), and less frequent maternal hypoglycemia (<60 mg/dL [3.3 mmol/L], 6.1 percent pre- versus 2.5 percent post). The intravenous insulin protocol [17] includes an infusion of 10 percent dextrose at 50 mL per hour if the patient is not hyperglycemic (ie, it is initiated if blood glucose is <160 mg/dL [8.9 mmol/L]). We typically use 5 percent dextrose at 75 to 125 mL per hour.

  - A small observational study of intrapartum use of a computer-driven insulin infusion protocol reported the protocol improved mean glucose (103 mg/dL versus 122 mg/dL [5.7 versus 6.8 mmol/L]) and increased the proportion of patients who achieved target blood glucose by delivery (82 versus 9 percent), without a significant difference in maternal hypoglycemia (0 versus 4 percent) when compared with a "standard" insulin infusion protocol based on the current blood glucose level alone

[20]. The computer algorithm calculates the insulin infusion rate based on the current blood glucose plus a "multiplier," which starts at a standard figure and increases or decreases depending on whether the blood glucose is in the target range [21].

Patients on insulin pumps — Many pregnant people with type 1 diabetes use continuous subcutaneous insulin infusion (CSII or pump therapy) to manage glycemia antenatally and prefer to remain on their insulin pump during labor and throughout their delivery hospitalization. Although data are limited, this is reasonable as a randomized trial (70 participants) found no significant difference in first neonatal blood glucose (primary outcome) or any secondary neonatal outcomes in patients assigned to use their own insulin pump during labor versus intravenous insulin infusion [22]. Participants assigned to intravenous insulin had more maternal hyperglycemia during labor (maternal glucose >200 mg/dL [11.1 mmol/L]). A prospective observational study also reported that advanced hybrid closed-loop therapy was safe and effective in maintaining target glucose levels intrapartum and in the early postpartum period [23]. (See "Management of blood glucose in adults with type 1 diabetes mellitus", section on 'Continuous subcutaneous insulin infusion (insulin pump)'.)

- **For patients who prefer not to use their pumps or who are unable to self-manage their pump while hospitalized**, management of insulin infusion is the same as that for patients who normally take multiple daily insulin injections (see 'Patients on multiple daily insulin injections' above).

- **For patients who wish to use their own insulin pumps while in the hospital**, hospitals should have written policies/protocols. Those who use their pump during labor should move the infusion site away from the lower abdomen (eg, to the flank, thigh, or buttock). If the patient has persistent hyperglycemia on the insulin pump, the pump site, tubing, and control device should be evaluated to ensure they are working properly. We have a low threshold for switching to an insulin infusion for persistent hyperglycemia greater than target (>125 mg/dL [6.9 mmol/L]).

  - **Before food is restricted** – In the latent phase before food is restricted, patients using an insulin pump will continue to need prandial insulin coverage, which we typically provide by continuing the antenatal insulin pump settings. If the patient's blood glucose levels have been tightly controlled at home or if the patient is not eating full meals on the labor unit, we consider a dose reduction of 20 to 30 percent.

  - **After food is restricted** – Once food is restricted and/or the patient is in the active phase of labor, we start a constant infusion of dextrose-containing fluids in patients whose blood glucose is ≤125 mg/dL (6.9 mmol/L, a lower threshold for dextrose-containing fluids than for our insulin infusion protocol because of the presumed

lower risk of hypoglycemia when using the home insulin pump). This allows for a stable basal rate of subcutaneous insulin infusion that can be adjusted to achieve glycemic targets as labor progresses. Once we initiate the dextrose infusion, we continue it unless the patient is markedly hyperglycemic, and adjust the insulin pump basal rate based on the trends in blood glucose. Bolus insulin is administered through the pump to provide rapid correction of hyperglycemia.

Few protocols for intrapartum insulin pump management have been published:

- A multicenter retrospective study described a standardized protocol for intrapartum CSII in a series of 65 patients with type 1 diabetes [24]. The protocol involved using three potential basal rates. Patients who were euglycemic on presentation continued the basal rate at the last antepartum level; this was reduced to 30 to 70 percent of the last antepartum level when active labor began and intravenous glucose commenced. A lower basal rate of 0.1 to 0.2 units per hour was used if hypoglycemia developed.

- Another protocol suggests increasing or decreasing the pump basal rate by 20 percent as needed every hour to maintain glucose in the target range (with 10 percent dextrose infusion at 50 mL per hour if blood glucose was ≤100 mg/dL [5.6 mmol/L]) [17].

- The protocol in a randomized trial comparing intrapartum insulin pump versus intravenous insulin infusion described above involved increasing the pump basal rate by 5 to 20 percent for hyperglycemia, depending on the current blood glucose level and rate of change [22]. For hypoglycemia, the pump was suspended and intravenous dextrose was given.

- **Patients using hybrid closed-loop insulin pumps** – There are few data on the intrapartum use of the hybrid closed-loop insulin pumps available in the United States. These pumps are not approved by the US Food and Drug Administration (FDA) for pregnant individuals, but off-label use is increasingly common. The author's practice is to continue hybrid closed-loop insulin therapy intrapartum in patients who were using it off-label in pregnancy, provided that CGM readings remain congruent with frequent hospital glucometer blood glucose checks. Hospital policies on inpatient use of patient-managed insulin pumps vary widely.

Type 2 diabetes — Intrapartum insulin requirements vary widely in these patients and many require no administration of insulin because of the combination of food restriction and active labor.

Patients on multiple daily injections — Most patients with type 2 diabetes are treated in pregnancy with multiple daily insulin injections. (See "Preexisting (pregestational)

diabetes mellitus: Antenatal glycemic management".)

- **Before food is restricted** – Before labor and in the latent phase of labor before food is restricted, we typically provide 70 to 80 percent of the total daily dose of insulin that was used at home. The exact dose reduction from the home insulin regimen depends on the recent level of glycemic control, the patient diet, the blood glucose level on presentation, and the anticipated labor course.

  Approximately half of the hospital-provided total daily dose (35 to 40 percent of the home total daily dose) is given as intermediate-acting insulin (NPH) in two divided doses every 12 hours. We use NPH instead of longer-acting formulations because of the greater ease in making frequent adjustments. We may give an even lower dose of NPH insulin if active labor is anticipated in the next six to eight hours, given the duration of action of NPH and anticipated decline in insulin requirement with uterine contractions.

  Before labor and in the latent phase of labor before food is restricted, half of the hospital-provided total daily dose is given as rapid-acting insulin prior to meals in three divided doses (approximately 12 to 15 percent of the home total daily dose with each of three meals) plus correctional rapid-acting insulin (table 1).

- **After food restriction and/or in the active phase of labor**, we use either an intravenous insulin infusion according to a standardized protocol (such as that published by Dude et al [17]) or subcutaneous correctional insulin administered via a sliding scale every two to four hours (table 1). If the patient is very or persistently hyperglycemic (glucose >200 mg/dL [11.1 mmol/L] on presentation or glucose >125 mg/dL [6.9 mmol/L] on multiple checks), we use intravenous insulin infusion rather than subcutaneous insulin. Use of an insulin infusion for intrapartum glycemic management is recommended by ACOG [1].

  In active labor, we start a constant infusion of dextrose-containing fluids in patients whose capillary blood glucose is <160 mg/dL (8.9 mmol/L) if using an insulin infusion. In patients on subcutaneous correctional insulin, we start a constant infusion of dextrose-containing fluids in patients whose blood glucose is ≤125 mg/dL (6.9 mmol/L, a lower threshold because of a presumed lower risk of hypoglycemia when using subcutaneous versus intravenous insulin). Once we initiate the dextrose infusion, we continue it while adjusting the insulin infusion or administering the correctional subcutaneous insulin dose unless the patient is markedly hyperglycemic.

Patients on metformin or an insulin pump

- Metformin – For patients taking metformin at home, we hold this agent on admission to the hospital for delivery.

- **Insulin pump** – Patients managed with insulin pumps antepartum can be managed similarly to patients with type 1 diabetes who use pumps. (See 'Patients on insulin pumps' above.)

Gestational diabetes

- **Subcutaneous correctional insulin** – Patients with gestational diabetes can often be managed with subcutaneous correctional insulin during labor (table 2). If blood glucose levels are persistently above the goal of ≤125 mg/dL (6.9 mmol/L) despite subcutaneous insulin, insulin infusion can be initiated.

  A randomized trial comparing intensive glucose management (goal blood glucose 70 to 100 mg/dL [3.3-5.6 mmol/L], hourly monitoring) versus liberalized glucose management (goal blood glucose 70 to 120 mg/dL [3.9-6.7 mmol/L], every-four-hours monitoring) in patients with gestational diabetes using subcutaneous rapid-acting correctional insulin to manage intrapartum glycemia supports the use of a liberalized protocol in these patients, as shown in the table (table 2) [14]. In this trial, the mean neonatal blood glucose level in the first 24 hours of life was lower in the intensive management group, but neonatal hypoglycemia rates were similar in both groups.

- **Rotating fluids** – A strategy of "rotating fluids" (table 3) has also been used in patients with gestational diabetes, and reduced the need for intrapartum insulin infusion.

  A small randomized trial found similar mean glucose levels (103 mg/dL [5.7 mmol/L]) and neonatal outcomes in insulin-treated patients (primarily gestational diabetes) who were treated with the rotating fluids protocol and those receiving continuous insulin infusion to achieve glucose targets of 100 mg/dL (5.6 mmol/L) [25].

Special situations

Scheduled cesarean birth in patients receiving insulin

- When cesarean birth is planned in patients on insulin for diabetes, the procedure should be scheduled early in the morning.

- Patients on multiple daily injections should maintain their usual dose of NPH on the night prior to admission. If they use a longer-acting basal insulin at night (eg, glargine), the dose should be decreased by 20 to 50 percent, with the exact percentage dose reduction determined by the risk of morning hypoglycemia based on recent fasting self-monitored glucose values. Those on insulin pumps should generally maintain the basal rate until admission to the hospital, unless they are prone to early

morning hypoglycemia, in which case the overnight basal rate can be decreased by 20 to 50 percent.

- On the morning of the cesarean:

  - **Type 1 diabetes** – On the morning of the cesarean, patients on multiple daily injections who administer their basal insulin (other than insulin degludec) in the morning should administer either a) the anticipated postpartum dose or b) be admitted for possible intravenous dextrose on the morning of the cesarean and administer 50 to 70 percent of the most recent home morning basal insulin dose. If the cesarean will be delayed past the early morning, the latter approach should be taken. Insulin degludec is a long-acting insulin with a duration of action up to 42 hours. Thus, we hold the insulin degludec dose on the morning of a planned cesarean birth to prevent postpartum hypoglycemia [26].

  Patients on insulin pumps can continue using them if congruent with hospital policy. We reduce the basal insulin dose by approximately 20 percent if the patient is prone to morning hypoglycemia and switch to postpartum settings during or immediately after the procedure. Prandial insulin is held on the morning of the cesarean consistent with taking nothing by mouth status, but correctional insulin can be given if the blood glucose is above target (>125 mg/dL [6.9 mmol/L]).

  We provide dextrose-containing fluids if the blood glucose falls below 100 mg/dL (5.6 mmol/L).

  - **Type 2 or gestational diabetes** – On the morning of the cesarean, the dose of insulin can generally be held. If the cesarean will be delayed past the early morning, 50 to 70 percent of the usual basal insulin dose can be given and intravenous dextrose should be administered if the blood glucose is below 100 mg/dL (5.6 mmol/L).

- We monitor glucose levels every hour in patients with type 1, type 2, and gestational diabetes who take insulin because of their risk of developing hypoglycemia in the setting of taking nothing by mouth.

- Pre- and intraoperative hyperglycemia is treated with either intravenous insulin or subcutaneous rapid-acting insulin, as needed, to manage glucose levels.

- Corticosteroids are now frequently used as antiemetic prophylaxis during cesarean birth. However, the dosages typically used have significant effects on postpartum glycemia, thus we generally prefer to avoid them in most patients with diabetes. If used, they may increase postpartum insulin requirements beyond what is

recommended below. (See "Postoperative nausea and vomiting", section on 'Glucocorticoids'.)

- Postoperative management is discussed below. (See 'Postpartum management' below.)

Scheduled cesarean birth in patients using metformin — Patients using metformin should hold this medication on the morning of the cesarean.

Scheduled cesarean birth in patients with gestational diabetes managed with nutritional therapy alone — These patients are managed similarly to pregnant individuals without diabetes undergoing scheduled cesarean birth.

Induction of labor — Patients undergoing induction of labor can be managed similarly to those who have spontaneous labor. In patients on long-acting basal insulin (>24 hour duration of action), particularly multiparous patients who may have a shorter labor, some clinicians reduce the dose by 20 to 50 percent on the night prior to an induction of labor.

POSTPARTUM MANAGEMENT

Type 1 diabetes

Pathophysiology — Insulin requirements drop precipitously immediately after birth because pregnancy-associated insulin resistance rapidly dissipates after expulsion of the placenta [27]. The insulin requirement reaches a nadir at approximately 48 hours postpartum and is lower than the prepregnancy requirement [28]. Insulin resistance (and therefore insulin requirement) then increases over the subsequent two to four weeks postpartum, but does not reach prepregnancy levels as long as the individual is breastfeeding [29-31]. (See 'Breastfeeding mothers' below.)

Glycemic monitoring and targets

- Capillary blood glucose levels are monitored fasting, before meals, and at bedtime. The author also performs an overnight blood glucose check (at 2 or 3 AM) on the first two nights postpartum because of the risk of overnight hypoglycemia.

  If the patient is not eating, capillary blood glucose can be monitored every four to six hours. Given the risk of hypoglycemia and the need to administer basal insulin, dextrose-containing fluids are infused in patients who are not reliably eating.

- Maternal glucose targets can be relaxed postpartum because glycemic effects on fetal outcomes are no longer a concern. The targets are generally the same as those in other

hospitalized patients (<140 mg/dL [7.8 mmol/L] preprandial glucose, <180 mg/dL [10.0 mmol/L] any random glucose); the author prefers to keep the blood glucose above 100 mg/dL (5.6 mmol/L) in the first 24 to 28 hours postpartum given the high risk of hypoglycemia. (see "Management of diabetes mellitus in hospitalized patients", section on 'Glycemic targets').

Insulin management — If information about the prepregnancy dose is available, we initially provide 60 to 70 percent of the prepregnancy total daily insulin dose, with half given as basal insulin. Given that people with type 1 diabetes typically double their insulin requirements during pregnancy [32], this initial postpartum insulin dosing is usually 30 to 35 percent of the antenatal doses. However, close attention to glucose levels and adjustment of the insulin regimen in the first few days postpartum is necessary because of wide patient variation in insulin requirements, as demonstrated in a study of patients with type 1 diabetes using a closed-loop insulin delivery during labor and on days 1 and 2 postpartum [33]. Because insulin degludec is a long-acting insulin with a duration of action up to 42 hours, some clinicians hold the first postpartum insulin degludec dose after delivery to prevent postpartum hypoglycemia related to the higher doses administered prior to delivery [26].

Basal, prandial, and correctional insulin is provided via multiple daily injections or insulin pump (see "Management of blood glucose in adults with type 1 diabetes mellitus"). A correctional sliding scale for hospitalized postpartum patients on multiple daily injections is available in the table (table 4). Patients who were using hybrid closed-loop insulin pump therapy prior to pregnancy and suspended it during pregnancy may resume automated insulin delivery postpartum, but the exact timing of resumption should be determined by the specific hybrid closed-loop algorithm being used. Some algorithms rely on the insulin delivery in the preceding days to weeks, thus patients may need to run the pump without automated features temporarily to avoid overly aggressive insulin delivery based on pregnancy insulin requirements.

The only trial of use of a hybrid closed-loop insulin pump in the postpartum setting demonstrated less hypoglycemia (and without excess hyperglycemia) in those randomly assigned to closed-loop insulin delivery compared with those assigned to automated insulin suspension only [34]. However, participants were randomized at day 7 postpartum to avoid the issue of the need for the closed-loop system to adapt to rapid changes in insulin requirement in the immediate postpartum setting.

Close outpatient follow-up for insulin titration is important until the individual's insulin requirement stabilizes in the first two to four weeks postpartum.

Breastfeeding mothers — Insulin requirements remain 15 to 20 percent lower than prepregnancy requirements in breastfeeding mothers with type 1 diabetes [29-31,35].

Studies examining glucose control via continuous glucose monitoring (CGM) in individuals with type 1 diabetes and established breastfeeding (eg, one to two months after birth) suggest no increase in episodes of hypoglycemia compared with those feeding formula [36] or matched, nonpregnant [29] females with type 1 diabetes.

It has been suggested that breastfeeding individuals with type 1 diabetes should consume a minimum of 210 grams of carbohydrates daily [35].

Exogenous insulin use is compatible with breastfeeding; insulin is a normal component of human milk and is not expected to be orally bioavailable to the infant [35,37].

Type 2 diabetes

Pathophysiology — Insulin resistance rapidly dissipates after expulsion of the placenta, as described above (see 'Pathophysiology' above). Glucose levels tend to be normal or only modestly elevated in the immediate postpartum period in individuals with type 2 diabetes not receiving glucose-lowering therapy.

Glycemic monitoring and targets

- Capillary blood glucose levels are monitored fasting, before meals, and at bedtime during the postpartum hospitalization. The targets are generally the same as those in other hospitalized patients (<140 mg/dL [7/8 mmol/L] preprandial glucose, <180 mg/dL [10.0 mmol/L] any random glucose).

  After discharge, we ask patients who are not on insulin to monitor blood glucose levels twice daily (fasting and either two hours after the largest meal or at bedtime) to identify hyperglycemia in the first two to four weeks postpartum. While nonpregnant patients with type 2 diabetes on noninsulin agents do not necessarily have to monitor blood glucoses on a regular basis and can be monitored with A1C, the A1C is not reliable in the immediate postpartum period due to alterations in red blood cell turnover that occur during pregnancy and at delivery.

Insulin management — Many patients who were not on insulin before pregnancy or who started insulin in the setting of planning pregnancy can stop insulin in the immediate postpartum period. In the minority of patients who were on long-standing insulin therapy prior to pregnancy, we follow a similar management plan as for type 1 diabetes (see 'Insulin management' above), with the addition of metformin if not contraindicated. Patients who were not on long-standing insulin therapy should continue or initiate metformin if no contraindication exists and start additional noninsulin therapies as indicated (see below).

Metformin management — In patients with type 2 diabetes, we start or continue metformin after birth if there are no contraindications. Metformin is first-line therapy in type 2 diabetes and in the absence of other contraindications should be continued even if other agents are used. (See "Metformin in the treatment of adults with type 2 diabetes mellitus", section on 'Contraindications'.)

We start with 500 mg orally once daily with food and increase the total daily dose by 500 mg weekly until a target dose of 1000 mg twice daily is reached. (See "Initial management of hyperglycemia in adults with type 2 diabetes mellitus" and "Metformin in the treatment of adults with type 2 diabetes mellitus".)

While the patient is hospitalized, in addition to metformin, hyperglycemia is treated using correctional insulin dosed via a sliding scale before meals (table 4). The sliding scale insulin is discontinued prior to discharge. For patients who are not meeting glycemic targets despite metformin, combination therapy is necessary to achieve optimal results (see "Initial management of hyperglycemia in adults with type 2 diabetes mellitus", section on 'Persistent hyperglycemia'). Options for additional therapies for those who have contraindications to metformin or who are persistently hyperglycemic on metformin are limited in breastfeeding patients (see 'Breastfeeding mothers' below). Patients who are not breastfeeding can be treated similarly to other nonpregnant patients. (See "Initial management of hyperglycemia in adults with type 2 diabetes mellitus", section on 'Persistent hyperglycemia'.)

Other diabetes medications — Other diabetes medications can be used in the postpartum setting, similar to use outside of pregnancy, but most options (other than insulin and metformin) are not compatible with breastfeeding (see below).

Breastfeeding mothers — Breastfeeding is encouraged in mothers with type 2 diabetes and may have metabolic benefits. (See "Preexisting (pregestational) diabetes mellitus: Obstetric issues and pregnancy management".)

Metformin is excreted at low levels in breastmilk and is considered compatible with breastfeeding [38]. Exogenous insulin use is also compatible with breastfeeding [35,37].

If additional pharmacologic therapy beyond or instead of metformin or insulin is needed, glyburide [39] is considered compatible with breastfeeding (see "Breastfeeding: Parental education and support", section on 'Maternal medication safety').

Data on GLP-1 receptor agonists and SGLT2-inhibitors in lactation are not available, thus are **not** recommended in breastfeeding patients. In particularly, SGLT2-inhibitors have high oral bioavailability and were present in the milk of lactating animals who were administered these medications. Thus, there is considerable concern for infant exposure and adverse effects if a lactating parent uses these medications.

Gestational diabetes

Pathophysiology — Insulin resistance rapidly dissipates after expulsion of the placenta, as described above (see 'Pathophysiology' above). Diabetes medications are not routinely given after birth to patients with gestational diabetes as glucose levels tend to be normal without exogenous glucose-lowering therapy.

Glucose monitoring and targets

- Many obstetrics services, including our own, assess fasting glucose levels 24 to 72 hours after birth to check for overt diabetes (fasting glucose ≥126 mg/dL [7.0 mmol/L]) in patients with gestational diabetes and continue to treat patients with hyperglycemia. A normal postpartum fasting glucose does not obviate the need for additional postpartum glucose testing. Typically, this consists of a two-hour oral glucose tolerance test at 4 to 12 weeks postpartum. However, some obstetrics services are now performing an early two-hour oral glucose tolerance test during the delivery hospitalization. If overt diabetes is not diagnosed while the patient is in the hospital postpartum, follow-up for development of overt diabetes is recommended. Follow-up is discussed in detail separately. (See "Gestational diabetes mellitus: Glucose management, maternal prognosis, and follow-up", section on 'Follow-up' and "Gestational diabetes mellitus: Obstetric issues and management", section on 'Screening for overt diabetes'.)

Breastfeeding — Based on observational studies, breastfeeding may prevent the development of type 2 diabetes in mothers with a history of gestational diabetes (See "Gestational diabetes mellitus: Obstetric issues and management", section on 'Breastfeeding'.)

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Diabetes mellitus in pregnancy".)

INFORMATION FOR PATIENTS

UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th

grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Basics topics (see "Patient education: Care during pregnancy for people with type 1 or type 2 diabetes (The Basics)")
- Beyond the Basics topics (see "Patient education: Care during pregnancy for patients with type 1 or 2 diabetes (Beyond the Basics)")

SUMMARY AND RECOMMENDATIONS

- **Type 1 diabetes**
  - **Patients on multiple daily injections**
    - In **early labor**, if food is not restricted, the patient on multiple daily insulin injections follows their home subcutaneous insulin regimen, including basal, prandial, and correctional coverage. If the patient's blood glucose levels have been tightly controlled at home or if the patient is not eating full meals on the labor unit, a dose reduction may be necessary. (See 'Patients on multiple daily insulin injections' above.)
    - Once food is restricted and/or the **active phase** is reached, an intravenous insulin infusion is started using a standardized protocol. Dextrose-containing intravenous fluids are administered along with the insulin infusion as long as the patient is not hyperglycemic (ie, administer if blood glucose <160 mg/dL [8.9 mmol/L]). (See 'Patients on multiple daily insulin injections' above.)
    - **Postpartum** insulin requirements in the first few days are lower than prior to pregnancy, reaching a nadir at 48 hours before increasing and stabilizing by two to four weeks after birth. If the prepregnancy insulin dosages are known, we provide an initial postpartum regimen that is 60 to 70 percent of the prepregnancy regimen. This usually equates to insulin dosages that are 30 to 35 percent of the insulin dosages prior to delivery. Postpartum insulin requirements vary widely; close monitoring and adjustment are needed. (See 'Insulin management' above and 'Glycemic monitoring and targets' above.)

      In **breastfeeding** patients with type 1 diabetes, insulin requirements may remain 15 to 20 percent lower than prior to pregnancy. (See 'Breastfeeding mothers' above.)

- **Patients who use an insulin pump** may continue to do so intrapartum if hospital policies allow, but need to move the infusion site away from the lower abdomen (eg, to the flank, thigh, or buttock), which is used for contraction and fetal monitoring. Data on the use of hybrid closed-loop insulin pumps in the intrapartum and postpartum period are limited. (See 'Patients on insulin pumps' above.)

- **Target blood glucose levels** are 70 to 125 mg/dL (3.9 to 6.9 mmol/L) during active labor. Higher blood glucose levels have been associated with fetal acidemia and neonatal hypoglycemia. These levels may be relaxed after birth (<140 mg/dL [7.8 mmol/L] preprandial glucose, <180 mg/dL [10.0 mmol/L] any random glucose) and until the patient stabilizes to avoid hypoglycemia. (See 'Glycemic targets' above and 'Glycemic monitoring and targets' above.)

- **Type 2 diabetes**

  - **In early labor, if food is not restricted**, the patient on multiple daily insulin injections takes 70 to 80 percent of the home antenatal total daily insulin dose. Half of this provided dose is given as intermediate-acting insulin (NPH) in two divided doses every 12 hours. The other half is given as standing prandial rapid-acting insulin in three divided doses before meals. Correctional rapid-acting insulin is also given before meals (table 1). (See 'Patients on multiple daily injections' above.)

  - **After food restriction and/or in the active phase of labor**, either an intravenous insulin infusion or correctional insulin administered via a sliding scale every two to four hours (table 1) is acceptable. Dextrose-containing fluids are infused if the patient is not hyperglycemic. If the patient is very or persistently hyperglycemic (glucose >200 mg/dL [11.1 mmol/L] on presentation or glucose >125 mg/dL [6.9 mmol/L] on multiple checks), we use an intravenous insulin infusion rather than subcutaneous insulin. (See 'Intrapartum management' above.)

  - **Patients on** metformin should hold this medication during labor. (See 'Patients on metformin or an insulin pump' above.)

  - **Patients managed with insulin pumps antepartum** can be managed similarly to patients with type 1 diabetes who use pumps. (See 'Patients on insulin pumps' above.)

  - **Postpartum** – Most patients with type 2 diabetes should be treated with metformin unless there are contraindications. Those who were on long-standing insulin before pregnancy should follow a similar management plan as for type 1 diabetes, with the addition of metformin. Breastfeeding may have metabolic benefits and should be encouraged, but options for agents to treat hyperglycemia in breastfeeding patients are limited to metformin, glyburide, and insulin. (See 'Metformin management' above and 'Insulin management' above.)

- **Gestational diabetes**

  - During labor, patients with gestational diabetes can often be managed with subcutaneous correctional insulin (table 1). If blood glucose levels are persistently above the goal of 125 mg/dL (6.9 mmol/L) despite subcutaneous insulin, insulin infusion can be initiated.

  - Close follow-up for the development of overt diabetes is required. Choice of test, timing, interpretation, and ongoing testing are discussed separately. (See "Gestational diabetes mellitus: Glucose management, maternal prognosis, and follow-up", section on 'Follow-up'.)

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Topic 4441 Version 48.0

GRAPHICS

Correctional rapid-acting subcutaneous insulin scale for intrapartum use

Patients on 40 to 79 total units of insulin per day*	
Blood sugar	**Rapid-acting insulin dose**
≤125 mg/dL	0 units
126 to 150 mg/dL	1 unit
151 to 175 mg/dL	2 units
176 to 200 mg/dL	3 units
>200 mg/dL	Start intravenous insulin infusion
Patients on 80 to 139 total units of insulin per day	
Blood sugar	**Rapid-acting insulin dose**
≤125 mg/dL	0 units
126 to 150 mg/dL	2 units
151 to 175 mg/dL	4 units
176 to 200 mg/dL	6 units
>200 mg/dL	Start intravenous insulin infusion
Patients on 140 to 200 total units of insulin per day*	
Blood sugar	**Rapid-acting insulin dose**
≤125 mg/dL	0 units
126 to 150 mg/dL	3 units
151 to 175 mg/dL	6 units
176 to 200 mg/dL	9 units
>200 mg/dL	Start intravenous insulin infusion

* Patients on <40 or >200 units of insulin per day may require customized correctional insulin.

Graphic 135227 Version 1.0

Liberalized glycemic control protocol for use in laboring patients with gestational diabetes

Blood glucose (mg/dL), monitored every 4 hours	Rapid-acting insulin administered
≤120*	0 units
121-150	2 units
151-200	4 units
>200	8 units

* When the blood sugar is <60 mg/dL, juice is provided to treat hypoglycemia.

Data from: Hamel MS, Kanno LM, Has P, et al. Intrapartum Glucose Management in Women With Gestational Diabetes Mellitus: A Randomized Controlled Trial. Obstet Gynecol 2019; 133:1171.

Graphic 135238 Version 1.0

Rotating fluids protocol

Maternal plasma glucose	Intravenous insulin (units/hour)*[1]	Intravenous solution
"Rotating fluids." For use in women with gestational diabetes. This protocol should not be used in women with type 1 or type 2 diabetes mellitus.		
≤100 mg/dL (5.6 mmol/L)	Hold	D5NS at 125 mL/hour to achieve CBG of 100 mg/dL (5.6 mmol/L)
101 to 140 mg/dL (5.6 to 7.8 mmol/L)	Hold	Lacted Ringers or normal saline at 125 mL/hour to achieve CBG of 100 mg/dL (5.6 mmol/L)
>140 mg/dL (7.8 mmol/L)	Short- or rapid-acting insulin infusion titrated to achieve CBG of 100 mg/dL (5.6 mmol/L)	Lacted Ringers or normal saline at 125 mL/hour to achieve CBG of 100 mg/dL (5.6 mmol/L)

CBG: capillary blood glucose; D5NS: 5 percent dextrose normal saline.

* Mix 25 units regular insulin in 250 mL normal saline (1 unit:10 mL).

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Graphic 76661 Version 12.0

Correctional insulin sliding scale for postpartum use

Weight <75 kg (165 pounds)	
Blood glucose	**Rapid-acting insulin**
<150 mg/dL [8.3 mmol/L]	0 units
151 to 199 mg/dL [8.4 to 11.0 mmol/L]	1 unit
200 to 249 mg/dL [11.1 to 13.8 mmol/L]	2 units
250 to 299 mg/dL [13.9 to 16.6 mmol/L]	3 units
300 to 350 mg/dL [16.7 to 19.4 mmol/L]	4 units
351 to 400 mg/dL [19.5 to 22.2 mmol/L]	5 units
Weight ≥75 kg (165 pounds)	
Blood glucose	**Rapid-acting insulin**
<150 mg/dL [8.3 mmol/L]	0 units
151 to 199 mg/dL [8.4 to 11.0 mmol/L]	2 units
200 to 249 mg/dL [11.1 to 13.8 mmol/L]	4 units
250 to 299 mg/dL [13.9 to 16.6 mmol/L]	6 units
300 to 350 mg/dL [16.7 to 19.4 mmol/L]	8 units
351 to 400 mg/dL [19.5 to 22.2 mmol/L]	10 units

Graphic 138403 Version 1.0

Contributor Disclosures

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