Timing of induction of labor

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A R T I C L E   I N F O

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A B S T R A C T

Determining the optimal timing for induction of labor is critical in minimizing the risks to maternal and fetal health. While data are available to guide us in some clinical situations, such as hypertension and diabetes, many gaps in knowledge still exist in others, including cholestasis of pregnancy, fetal anomalies, and placental abruption. This review of the currently available literature assesses the risks and benefits of preterm and early term induction in a wide variety of maternal and fetal conditions.

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Introduction

Induction of labor is considered when risks to maternal or fetal health outweigh the risks of an early delivery. However, it is difficult to calculate these risks with precision. Many factors must be weighed, including gestational age, severity of the condition, potential for impending maternal or fetal complications, and cervical exam.

From the fetal perspective, iatrogenic preterm and early term deliveries have been associated with increased neonatal and long-term developmental complications, while expectant management introduces the risks of stillbirth, infectious complications in pregnancies with cervical dilation or rupture of membranes, and worsening hypoxia in pregnancies at risk for placental dysfunction. From the maternal perspective, induction of labor in the setting of an unfavorable cervix is associated with longer labors, risks of endometritis, postpartum atony and hemorrhage, and potentially an increased risk of cesarean deliveries.

After almost 20 years of steadily increasing rates of induction of labor, aggressive educational campaigns by the American College of Obstetricians and Gynecologists (ACOG), Society for Maternal–Fetal Medicine (SMFM), March of Dimes, and many state health departments have led to small declines in the overall rates of induction (from 23.8% in 2010 to 23.3% in 2012) with significantly larger declines in the rates of induction in the late-preterm period (34–36 6/7 weeks’ gestation) and the early term period (37–38 6/7 weeks’ gestation)Fig.

Although elective deliveries before 39 weeks are becoming rare, there are both maternal and fetal indications that should lead to earlier delivery. In an effort to elucidate the current state of the evidence behind these indications, the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) and SMFM held a workshop in February 2011 titled “Timing of Indicated Late-Preterm and Early Term Births.” This workshop reviewed available evidence and gaps in the literature needed to guide management in many clinical situations. Combining the results of this workshop with subsequent data, we present the current recommendations for timing of induction of labor in a wide variety of clinical situations.

Timing of induction of labor for maternal and obstetric indications

There is evidence that timely induction of labor can improve maternal and fetal outcomes for many maternal conditions.
Specifically, hypertension and diabetes have been studied extensively while less evidence exists for cholestasis of pregnancy. Induction for premature and preterm premature rupture of membranes will be discussed in “Labor induction in the patient with preterm premature rupture of membranes”, in this issue.

**Chronic hypertension**

The diagnosis of chronic hypertension either antedates pregnancy or is made prior to 20 weeks’ gestation. Approximately 1–5% of pregnancies are complicated by chronic hypertension, and the prevalence is expected to rise in the future with advancing maternal age and increased rates of maternal obesity. Chronic hypertension is associated with maternal morbidities like superimposed preeclampsia, stroke, and cesarean delivery in addition to adverse pregnancy outcomes including iatrogenic preterm birth, low birth weight, and fetal demise. There is evidence that the risk of adverse pregnancy outcomes is higher in women with increased severity of chronic hypertension.

No randomized controlled trials exist to guide decision making for the timing of delivery in women with chronic hypertension. A cohort study of women with chronic hypertension found that delivery at 38–39 weeks’ gestation was optimal for balancing fetal and neonatal risks. ACOG and SMFM suggest delivery at 38–39 weeks for women with chronic hypertension not requiring medication, 37–39 weeks for women controlled with medication, and 36–37 weeks for women with uncontrolled hypertension. These recommendations are somewhat extrapolated from data in women with gestational hypertension as discussed below. The timing of delivery will also be influenced by the development of complications, including fetal growth restriction and superimposed preeclampsia.

**Gestational hypertension**

Gestational hypertension is diagnosed after 20 weeks of gestation. This diagnosis involves elevated blood pressure in the absence of proteinuria. Gestational hypertension is the most common cause of hypertension of pregnancy with a reported incidence ranging from 2% to 17%. Severe gestational hypertension is associated with preterm birth, placental abruption, and small for gestational age infants. Up to 46% of women with gestational hypertension will develop preeclampsia.

Given the high risk of progression to preeclampsia, induction of labor is recommended for gestational hypertension. However, the optimal timing of delivery remains controversial. A randomized controlled trial in women with either gestational hypertension or preeclampsia without severe features found that induction of labor at 37 weeks’ gestation was associated with a significant decrease in composite maternal morbidity. Barton et al. found increased neonatal complications among women with gestational hypertension who delivered at 34–36 weeks’ gestation. A retrospective cohort study from the Consortium on Safe Labor in women with gestational hypertension found the lowest risk of maternal morbidity and mortality with induction of labor at 38 weeks. Conversely, the lowest risk of neonatal morbidity occurred with induction of labor at 39 weeks. ACOG and SMFM suggest delivery at 37–38 weeks for women with gestational hypertension.

**Preeclampsia**

Preeclampsia is a diagnosis made after 20 weeks’ gestation that includes the development of hypertension and either proteinuria or end-organ dysfunction. It occurs in approximately 3–5% of all pregnancies. Preeclampsia is considered to have severe features when women develop severe hypertension or evidence of end-organ dysfunction. Eclampsia occurs when women with preeclampsia experience a grand mal seizure. Preeclampsia and eclampsia are some of the leading causes of maternal mortality worldwide. Preeclampsia is also associated with placental abruption, acute kidney injury, cerebral hemorrhage, hepatic failure, pulmonary edema, fetal growth restriction, preterm birth, and increased neonatal morbidity and mortality.

The management of preeclampsia without severe features was investigated in a randomized controlled trial in combination with gestational hypertension as mentioned above. This study found a significant decrease in composite maternal morbidity with induction of labor at 37 weeks as compared with expectant management. There was no difference in neonatal outcomes between the 2 groups. No randomized trials have been performed in women with preeclampsia without severe features at less than 37 weeks’ gestation. Habli et al. compared neonatal outcomes in pregnancies complicated by preeclampsia or gestational hypertension and in normal pregnancies undergoing induction of labor at 35–36 weeks. They found higher rates of NICU admission, longer neonatal hospitalization, and increased risk of neonatal respiratory distress syndrome. ACOG and SMFM recommend induction of labor for preeclampsia without severe features at 37 weeks’ gestation.

The management of preeclampsia with severe features has been studied in 4 randomized controlled trials comparing induction of labor prior to 34 weeks’ gestation with expectant...
management. A systematic review of these trials found that induction of labor prior to 34 weeks was associated with decreased birth weight, higher rates of NICU admission, longer neonatal hospitalization, and increased neonatal complications including intraventricular hemorrhage and respiratory distress syndrome. Women who underwent induction of labor prior to 34 weeks were also more likely to have a cesarean delivery. However, the study sample sizes were inadequate to determine if induction of labor prior to 34 weeks is associated with differences in maternal outcomes when compared to expectant management. Induction of labor at 30–34 weeks’ gestation has also been compared to immediate cesarean section in patients with preeclampsia with severe features in several case series. These case series largely found no adverse effects of induction of labor, but they identified a high rate of cesarean section following attempted induction. ACOG and SMFM recommend induction of labor at 34 weeks’ gestation in patients with preeclampsia with severe features. Induction of labor for preeclampsia with severe features is also recommended in patients with unstable maternal or fetal conditions at gestational ages less than 34 weeks.

Immediate induction of labor is recommended following maternal stabilization in women with eclampsia regardless of gestational age. A small case series demonstrated favorable neonatal pulmonary outcomes without significantly increasing maternal risks by postponing delivery in women with eclampsia less than 32 weeks’ gestation in order to administer corticosteroids for fetal lung maturity. However, several other studies have shown that prolongation of pregnancy after eclampsia is associated with increased maternal and neonatal morbidity and mortality. ACOG and SMFM advise no delay in moving toward delivery following the diagnosis of eclampsia.

**Pregestational diabetes**

Pregestational diabetes, including both type 1 and type 2 diabetes, is present in approximately 1% of all pregnancies. The incidence is rapidly increasing likely secondary to the obesity epidemic. Pregestational diabetes is associated with adverse maternal and perinatal outcomes. Maternal complications include preeclampsia, progression of diabetic retinopathy, worsening diabetic nephropathy, and diabetic ketoacidosis. Adverse perinatal outcomes including major congenital anomalies, preterm birth, fetal demise, fetal macrosomia, shoulder dystocia, neonatal hypoglycemia, and respiratory distress syndrome increase in pregnancies complicated by pregestational diabetes.

Timing of induction of labor for pregestational diabetes is determined based on glycermic control with consideration of potential fetal and neonatal complications. ACOG suggests that patients with well-controlled diabetes can progress to 40 weeks’ gestation with reassuring antenatal testing. Neonatal respiratory distress syndrome is more common prior to 39 weeks in infants of women with pregestational diabetes than infants of women without diabetes. However, earlier delivery at 37–39 weeks is recommended in women with vascular complications or poorly controlled diabetes. There is a randomized trial of induction of labor at 38 weeks’ gestation vs. expectant management for insulin-requiring diabetes, but only 6% of the study population had pregestational diabetes. This study found that fetal macrosomia was significantly reduced in those undergoing induction of labor.

**Gestational diabetes**

Gestational diabetes is typically diagnosed when newly recognized hyperglycemia occurs in the second half of pregnancy. More than 90% of patients with diabetes in pregnancy carry this diagnosis. Potential complications of gestational diabetes include preeclampsia, cesarean delivery, fetal macrosomia, neonatal hypoglycemia, and shoulder dystocia. As mentioned above, a randomized controlled trial primarily comprising women with insulin-dependent gestational diabetes found that induction of labor at 38 weeks was associated with a reduction in fetal macrosomia with no differences in other maternal or fetal morbidities. Another cohort study showed that induction of labor at 38–39 weeks’ gestation for women with insulin-dependent gestational diabetes decreased the risk of shoulder dystocia compared with expectant management. Rosenstein et al demonstrated in a large cohort study that the risk of stillbirth significantly outweighs the risk of infant mortality with expectant management of gestational diabetes after 39 weeks. However, the number needed to induce at 39 weeks to prevent one perinatal death was 1518. The available evidence is not sufficient to recommend an optimal time for induction of labor for gestational diabetes. As with pregestational diabetes, delivery timing will depend on glycemic control. There is no evidence that an early induction of labor is beneficial in patients with adequate glycemic control. ACOG and SMFM recommend that delivery timing for women with poorly controlled gestational diabetes be individualized at late preterm or early term.

**Cholestasis of pregnancy**

Intrahepatic cholestasis of pregnancy is a diagnosis of exclusion primarily occurring in the third trimester that involves pruritus and elevation in serum bile acids. The reported prevalence varies widely. In most areas, the prevalence is less than 2%, but it can be as high as 25% in some populations in South America. The etiology of intrahepatic cholestasis is rare, this disease has been reported to carry a significant risk to the fetus. Potential fetal and neonatal complications include intrauterine demise, meconium-stained amniotic fluid, preterm birth, and respiratory distress syndrome. The incidence of fetal demise in patients with intrahepatic cholestasis after 37 weeks’ gestation is approximately 1.2%, and the risk seems to increase with increasing gestational age and bile acid levels. A recent retrospective study found that serum bile acid levels of 100 µmol/L or more are associated with adverse pregnancy outcomes. There are no available antenatal tests to accurately predict an increased...
risk of fetal demise in patients with intrahepatic cholestasis of pregnancy.\textsuperscript{43}

While induction of labor is advised for pregnancies complicated by intrahepatic cholestasis, the exact timing of delivery is debated.\textsuperscript{43} There are no randomized trials investigating the optimal gestational age for delivery. A case-control study found no difference in perinatal mortality when comparing induction of labor at 38 weeks’ gestation in women with intrahepatic cholestasis of pregnancy to expectant management of controls without intrahepatic cholestasis.\textsuperscript{43} Another case series following 206 pregnant women with intrahepatic cholestasis found that rates of intrauterine fetal demise were lower than in historic controls when induction of labor was performed at 37 weeks’ gestation.\textsuperscript{46} A decision-analytic model reported that delivery at 36 weeks of gestation was optimal for balancing risk of fetal demise and potential morbidities from early delivery.\textsuperscript{47} Both ACOG and SMFM identify cholestasis of pregnancy as an example of a medical indication for either a late-preterm or early term delivery, but they do not provide more detailed guidelines.\textsuperscript{48} An evidence-based recommendation regarding timing of delivery for intrahepatic cholestasis cannot be made until adequate randomized controlled trials are performed.

### Timing of induction of labor for fetal and placental indications

With few exceptions, induction of labor and delivery timing for fetal indications are guided primarily by observational studies and expert opinion. In addition to the data presented here for induction in the setting of fetal growth abnormalities, oligohydramnios, multiple gestations, fetal anomalies, and placenta abruption below, induction of labor for fetal demise will be discussed in “Management of stillbirth delivery”, in this issue.

#### Intrauterine growth restriction

Intrauterine fetal growth restriction is associated with increased perinatal morbidity and stillbirth, particularly at estimated fetal weights less than the fifth percentile. The optimal route and timing of delivery of growth-restricted fetuses should be determined by underlying maternal and/or fetal indications. In general, cesarean delivery is not indicated for isolated growth restriction and labor induction at term should be considered. ACOG supports delivery at 38 0/7 to 39 6/7 weeks’ gestation for isolated growth restriction or sooner in the presence of additional neonatal or maternal comorbidities.\textsuperscript{49}

The Disproportionate Intrauterine Growth Intervention Trial at Term (DIGITAT), a multicenter randomized trial of labor induction (n = 321) and expectant management (n = 329), found no significant difference in a composite outcome of neonatal death, low APGAR score, and umbilical cord artery pH, and admission to NICU.\textsuperscript{50} Furthermore, there was no difference in the rate of cesarean or operative vaginal delivery. The study authors found a significant increase in neonatal admission to intermediate care in the labor induction group. However, there was an increase in low birth weight less than the third percentile in the expectant monitoring group compared with the labor induction group (30.6% vs. 12.5%). Similarly, Visentin et al.\textsuperscript{51} showed that neonatal outcomes and rate of cesarean delivery of prenatally recognized small for gestational age (SGA) fetuses were not affected by induction of labor. Ofir et al.\textsuperscript{52} conducted a retrospective review of delivery records from a single institution and found that rates of cesarean delivery and some neonatal complications (e.g., respiratory complications) were higher in women with small for gestational age fetuses when induced at 37–39 weeks compared with women induced after 39 weeks’ gestation. A follow-up analysis of participants included in the DIGITAT by Boers et al.\textsuperscript{53} again reported comparable rates of neonatal morbidity among both delivery groups and concluded that induction of labor to prevent stillbirth may be considered after 38 weeks of gestation. Van wyk et al.\textsuperscript{54} found no difference in overall behavior and developmental outcomes using a postnatal parental assessment of children included in DIGITAT after a 2-year follow-up. A recent cost analysis of labor induction vs. expectant management in the DIGITAT found no economic benefit or improvement in outcomes after 38 weeks of gestation.\textsuperscript{55}

### Suspected fetal macrosomia

Fetal macrosomia is defined as birth weight greater than 4000 or 4500 g, regardless of gestational age, and is associated with both neonatal and maternal complications, including shoulder dystocia, brachial plexus injury, and obstetric hemorrhage.\textsuperscript{56,57} In 1997, Conen et al.\textsuperscript{58} published one of the first randomized trials on labor induction in the setting of suspected fetal macrosomia. In this trial of 273 women with an ultrasound-estimated fetal weight 4000–4500 g, there were no significant differences in shoulder dystocia and cesarean delivery in women undergoing induction of labor compared to women in the expectant management arm. The positive predictive value in detecting macrosomia in the study was 56.7%.\textsuperscript{58} Other studies have reported similar findings of poor sensitivity and positive predictive value in predicting birth weights greater than 4000 g.\textsuperscript{57,59,60} Several review articles have further supported the argument that data are insufficient to recommend induction of labor for suspected macrosomia.\textsuperscript{57,61–63}

However, recent data lend evidence to the benefits of labor induction in cases of suspected macrosomia. Using 2003 birth data, Cheng et al.\textsuperscript{64} found that women with infants having a birth weight of at least 4000 g undergoing induction of labor at 39 weeks had a lower rate of cesarean delivery compared with women delivering at later gestational ages. More recently, Bouvier et al.\textsuperscript{65} published a large international multicenter randomized trial comparing induction of labor at 37 0/7–38 6/7 weeks’ gestation and expectant management. A total of 822 women with singleton gestations whose estimated fetal weight was greater than 95% were randomized, with 407 women in the labor induction arm and 411 women in the expectant management arm included in the final analysis. There was a significant decrease in the primary composite outcome (shoulder dystocia, clavicle fracture, brachial plexus injury, intracranial hemorrhage, and neonatal death) among women who underwent labor induction (RR = 0.32; 95% CI: 0.15–0.71). Furthermore, there was no significant difference in the rate of cesarean delivery or
respiratory distress syndrome. While the recommendation may change based on recent evidence, ACOG and SMFM do not support labor induction for early term delivery in suspected macrosomia at the present time.48

**Oligohydramnios**

Oligohydramnios refers to a condition with decreased amniotic fluid volume, defined as a single deepest pocket <2 cm or amniotic fluid index (AFI) <5 cm. A meta-analysis by Nabhan and Abdelmoula66 reported higher rates of labor induction when AFI was used to classify oligohydramnios. Oligohydramnios may be idiopathic and occur as an isolated condition, but it may also be associated with conditions such as premature rupture of membranes, fetal growth restriction, multiple gestations, and fetal anomalies. As an isolated finding, oligohydramnios is not a sole indication for preterm delivery.67–70

Oligohydramnios has been associated with increased risk of cesarean delivery for fetal heart rate abnormalities and lower Apgar scores in some studies.71–73 However, an abundance of literature supports labor induction at term in the setting of oligohydramnios. In a prospective study of 79 women at greater than 34 weeks and with an AFI ≤5 cm, there was no difference in cesarean delivery for fetal distress, low umbilical cord pH, and variable and late decelerations compared to women with an AFI >5 cm.74 In another study by Rainford et al.75 of 232 women at term, an AFI <5 cm increased labor induction but not cesarean delivery for an abnormal fetal heart rate. Similar results were reported in a prospective case–control study by Venturini et al. In 120 patients with oligohydramnios matched to controls with normal amniotic fluid by Bishop score and gestational age, there was no significant difference in cesarean section or interval from labor induction to vaginal delivery.76

**Multiple gestations**

In a prospective observational study of 72 women with twin gestations greater than 36 weeks, there was a 63% success of labor induction with a higher success rates in women with lower mean BMIs.77 A recent retrospective cohort study compared 100 women with twin pregnancies to 100 randomly selected women with singleton pregnancies who delivered at the same institution. In women with twin gestations undergoing induction of labor, there was no difference in the route of delivery.78 Furthermore, the time from induction to vaginal delivery was similar for both twin and singleton pregnancies.

A small study of 17 women undergoing labor induction at 37 weeks compared to 19 women expectantly managed with twin gestations showed no significant difference in average birth weight or rate of cesarean delivery between the 2 groups.79 The Twins Timing of Birth Randomized Trial was a multicenter randomized trial conducted during 2003–2010.80 The primary outcome was a composite measure of adverse neonatal outcomes when comparing women with twin gestations electively delivered at 37 weeks to women delivered beyond 38 weeks. Induction of labor did not significantly reduce a woman’s chance of successful vaginal delivery. A recent Cochrane Review including the 2 aforementioned studies concluded that elective delivery at 37 weeks is not associated with adverse neonatal or maternal outcomes compared to women undergoing expectant management in uncomplicated twin gestations.81 ACOG and SMFM recommend delivery at 38 0/7–38 6/7 weeks for uncomplicated dichorionic–diamniotic twins and 34 0/7–37 6/7 weeks for uncomplicated monochorionic–diamniotic twins.8

**Fetal anomalies**

Induction of labor is the preferred approach to delivery for many common fetal anomalies. Similar to other fetal indications, there is a paucity of randomized trials and prospective studies to guide decision making on timing of labor induction for fetal anomalies. Historically, women with infants with known ventral wall defects were delivered by cesarean delivery. More recent data point to not only a shift to vaginal delivery for these infants but also some indicate a potential benefit of labor induction.82,83 In a retrospective review, How et al.84 identified 102 infants with isolated ventral wall defects (71 with gastrochisis and 31 with omphalocele) at 2 institutions. In all, 36 infants were delivered vaginally compared with 66 infants delivered by cesarean delivery. After adjusting for confounding factors, the authors found no difference in the primary outcomes of length of neonatal stay and number of days to enteral feeding in the infants delivered vaginally compared to those delivered by cesarean delivery. While not adequately powered, the authors found no difference in neonatal sepsis or death between groups. More recently, Baud et al. reviewed cases of gastrochisis during 1980–2011 at a single institution.85 Of the 208 infants who reached 37 weeks of gestation, 26.3% were delivered by cesarean delivery. Approximately 50% (n = 77) of the infants delivered vaginally underwent elective induction at 37 weeks. Compared with infants who were allowed to spontaneously labor, infants with gastrochisis delivered after labor was induced had significantly lower rates of neonatal sepsis and lower incidence of a composite outcome that included bowel damage and neonatal death. Length of neonatal hospital stay, time to oral feedings, and total time of parenteral nutrition were also decreased in the labor induction group, although these were not statistically significant. Similarly, Yang et al.81 found a decrease in length of neonatal hospital stay in women with fetal gastrochisis undergoing labor induction compared with women who were expectantly managed. These findings are supported by a recent Canadian Pediatric Surgery Network (CAPSNet) study. Using a national database for 2005–2013, CAPSNet identified 692 women with fetal gastrochisis. Compared with spontaneous labor, labor induction was associated with improved neonatal outcomes. Specifically, there was a significant decrease in both severe bowel matting (9% vs. 18.5%) and mean Gastrochisis Prognostic Score (1.19 vs. 1.64) among patients undergoing planned labor induction compared with those managed expectantly.86

There are no randomized trials that support labor induction for other fetal anomalies. In a study by Merrill et al.87 of 37 fetuses with meningomyelocele, there were no differences in immediate neonatal outcomes or long-term motor and/or sensory levels among women delivering vaginally compared to those undergoing cesarean delivery. Other potential considerations for labor induction are small neural tube defects.
teratomas, and head and necks lesions. In cases of post-term, or postdates, pregnancies continue beyond 42 0/7 weeks. Postdates labor induction at 37 weeks is insufficient in augmentation as there is already an ongoing release of prostaglandins caused by placental separation. Vaginal delivery is the preferred route in most cases and, after maternal stabilization and confirmation of a reassuring fetal heart rate, labor induction may be considered. Patients must be counseled on the risk of acute hemorrhage and fetal deterioration. Oftentimes, amniotomy is sufficient in augmentation as there is already an ongoing release of prostaglandins caused by placental separation. Labor induction at 37–38 weeks may also be considered in patients with chronic abruption or indeterminate cases and minimal bleeding as well as in the majority of cases with a fetal demise after the mother is stabilized.

Placental abruption

Placental abruption occurs in up to 1% of all pregnancies, with some studies reporting a higher incidence on pathologic examination of placentas. It occurs when the placenta separates prematurely from the uterine decidua and is associated with high rates of both maternal and perinatal morbidity and mortality. Management of placental abruption depends on several factors, including the acuity of bleeding, maternal stability, and fetal viability. A 2012 Cochrane review found no trials demonstrating the superiority of labor induction over cesarean delivery. However, ACOG supports labor induction for placental abruption but does not define criteria specifically. Vaginal delivery is the preferred route in most cases and, after maternal stabilization and confirmation of a reassuring fetal heart rate, labor induction may be considered. Patients must be counseled on the risk of acute hemorrhage and fetal deterioration. Oftentimes, amniotomy is sufficient in augmentation as there is already an ongoing release of prostaglandins caused by placental separation. Labor induction at 37–38 weeks may also be considered in patients with chronic abruption or indeterminate cases and minimal bleeding as well as in the majority of cases with a fetal demise after the mother is stabilized.

Postdates

Post-term, or postdates, pregnancies continue beyond 42 0/7 weeks’ gestation. Approximately 5–8% of pregnancies reach this gestational age, though the prevalence varies across countries depending on obstetric practices and prenatal assessment of gestational age. Early ultrasound examination for estimation of delivery date decreases the prevalence of post-term pregnancies. The etiology of post-term birth is not well understood, but risk factors include history of post-term pregnancy, obesity, nulliparity, and advanced maternal age.

Fetal, neonatal, and maternal adverse outcomes increase when pregnancies continue beyond term. The rates of stillbirth and neonatal mortality rise after 41 weeks’ gestation, but the absolute risk remains low. Post-term pregnancies have also been associated with perinatal complications, including fetal asphyxia, aspiration, peripheral nerve injury, and neonatal infection. Adverse maternal outcomes increased in post-term pregnancies include postpartum hemorrhage, cephalocele disproportion, and cesarean section. The long-term effects of post-term birth are not well studied.

Induction of labor is used in an effort to prevent the adverse outcomes of post-term pregnancies described above. A review of 22 randomized controlled trials of induction of labor at or beyond term found that a policy of induction of labor at 41–42 completed weeks of gestation was associated with decreased perinatal mortality and fewer cases of neonatal meconium aspiration syndrome compared with a policy of expectant management. In addition, there were fewer cesarean sections in the induction group compared with the expectant management group. The number needed to treat with induction of labor at 41–42 weeks was 416 in order to prevent 1 perinatal death. While this number is high, a survey of postpartum women demonstrated that patients also prefer induction of labor after 41 weeks over serial monitoring. Based on the available data described above, induction of labor at or beyond 41 weeks of gestation may reduce perinatal morbidity and mortality. Beyond 41 weeks of gestation, the alternative to induction of labor is expectant management with close fetal monitoring including twice weekly non-stress testing and amniotic fluid volume assessment with planned intervention for non-reassuring testing.

**Table – Evidence for timing of induction.**

<table>
<thead>
<tr>
<th>Indication</th>
<th>Timing of induction</th>
<th>Quality of evidence</th>
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<tbody>
<tr>
<td>Chronic hypertension</td>
<td>36–39 weeks</td>
<td>Low</td>
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<tr>
<td>Gestational hypertension</td>
<td>37–39 weeks</td>
<td>Moderate</td>
</tr>
<tr>
<td>Preeclampsia without severe features</td>
<td>37 weeks</td>
<td>Moderate</td>
</tr>
<tr>
<td>Preeclampsia with severe features</td>
<td>34 weeks (or less with unstable maternal or fetal conditions)</td>
<td>Moderate</td>
</tr>
<tr>
<td>Eclampsia</td>
<td>Immediate delivery after stabilization</td>
<td>Low</td>
</tr>
<tr>
<td>Pregestational diabetes</td>
<td>37–39 weeks</td>
<td>Low</td>
</tr>
<tr>
<td>Gestational diabetes</td>
<td>38–39 weeks</td>
<td>Low</td>
</tr>
<tr>
<td>Cholestasis of pregnancy</td>
<td>36–39 weeks</td>
<td>Very low</td>
</tr>
<tr>
<td>Intrauterine growth restriction</td>
<td>38–39 weeks</td>
<td>Moderate</td>
</tr>
<tr>
<td>Suspected fetal macrosomia</td>
<td>Mixed results, not currently recommended</td>
<td>Moderate</td>
</tr>
<tr>
<td>Oligohydramnios (isolated)</td>
<td>39 weeks</td>
<td>Low</td>
</tr>
<tr>
<td>Dichorionic twins</td>
<td>38 weeks</td>
<td>Moderate</td>
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<tr>
<td>Monochorionic–diamniotic twins</td>
<td>34–37 weeks</td>
<td>Low</td>
</tr>
<tr>
<td>Placental abruption</td>
<td>37–38 weeks</td>
<td>Low</td>
</tr>
<tr>
<td>Postdates</td>
<td>41–42 weeks</td>
<td>High</td>
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**Elective induction of labor**

The rate of non-medically indicated, or elective, induction of labor has risen over the last 2 decades.105 Multiple studies have identified an increased risk of neonatal and infant morbidity and mortality with delivery prior to 39 weeks' gestation.105 Of note, documentation of fetal lung maturity prior to 39 weeks' gestation does not eliminate the potential for neonatal respiratory or other complications.105 Induction of labor is not recommended prior to 39 weeks in the absence of an appropriate medical indication.48 Randomized trials are needed to determine the optimal gestational age for elective induction of labor after 39 weeks.

**Conclusion**

While most clinicians agree that determining the optimal timing for induction of labor is critical in minimizing the risks to maternal and fetal health, we are hindered in our ability to precisely determine where the risks and benefits intersect by the limited data available. In some clinical situations, such as hypertension and diabetes, the advantages of early term delivery have been determined by well-done retrospective and some prospective studies. Many gaps in knowledge still exist, however, in other conditions, including cholestasis of pregnancy, fetal anomalies, and placental abruption (Table). Specific prospective randomized trials are needed to ascertain the maternal and neonatal benefits of the timing of induction of labor for many important pregnancy situations.

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