Evaluation and Management of Fetal Macrosomia

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INTRODUCTION

Suspected fetal macrosomia is common in modern obstetrics. The delivery of large fetuses is clinically important because of the risk for maternal and neonatal complications. Data from the National Center for Health Statistics shows that in 2018, 7.8% of liveborn infants in the United States weighed more than 4000 g at birth, and 1% weighed more than 4500 g. About 0.1% weighed more than 5000 g. Potential maternal risks of macrosomia include an increased risk for Cesarean birth, protracted labor, uterine rupture, postpartum hemorrhage, third- and fourth-degree perineal lacerations, and infection. Potential neonatal risks include shoulder dystocia, bone fracture, brachial plexus injuries, low 5-minute Apgar scores, neonatal intensive care unit admission, hypoglycemia, polycythemia, meconium aspiration, respiratory problems, and in rare cases, asphyxial injury. Some studies suggest that fetal macrosomia can lead to childhood obesity, glucose intolerance, and development of metabolic syndrome later in life.

KEYWORDS

- Macrosomia
- Ultrasound
- Shoulder dystocia

KEY POINTS

- Macrosomia is most commonly defined as a birthweight exceeding 4000 g. Large for gestational age (LGA) is defined as birthweight greater than the 90th percentile at a given gestational age.
- Risk factors for macrosomia include maternal prepregnancy characteristics, maternal comorbidities, maternal obstetric history, fetal characteristics, and (rarely) genetic syndromes.
- Macrosomia can be diagnosed using clinical techniques, ultrasound, and maternal estimation. MRI is also being investigated. All techniques have limited accuracy in predicting macrosomia.
- Fetal macrosomia can result in shoulder dystocia, neonatal brachial plexus injury, and clavicle fracture.
DEFINITION OF MACROSOMIA

The terms macrosomia and large for gestational age (LGA) both refer to excessive fetal growth. Even though there is no universal agreement regarding the absolute threshold for macrosomia, historically it has been defined as a birthweight exceeding 4000 g independent of gestational age. The term large for gestational age refers to infants whose birthweight exceeds the 90th percentile for growth at a specific gestational age. The American College of Obstetricians and Gynecologists (ACOG) acknowledges that there is increased morbidity in infants with a birthweight greater than 4000 g, and the risks of adverse outcomes increase on a continuum as the birthweight increases. Thus, infants with a birthweight over 5000 g have higher morbidity than infants weighing 4500 to 4999 g, who in turn have higher morbidity than infants weighing 4000 to 4499 g. These increments of increased risk serve as the basis for a macrosomia grading system used by some clinicians in the decision-making process for mode of delivery: grade 1 for weight of 4000 to 4499 g, grade 2 for weight of 4500 to 4999 g, and grade 3 for weight over 5000 g.

RISK FACTORS FOR MACROSOMIA

There are several historic risk factors described in association with macrosomia. These risk factors, listed in Table 1, include maternal prepregnancy characteristics, maternal comorbidities, maternal obstetric history, fetal characteristics, and (rarely) genetic syndromes. One study found that macrosomia in a prior pregnancy was the single strongest individual risk factor for recurrent macrosomia. Many of the risk factors for macrosomia (male sex, parity, prior history of macrosomia, and maternal prepregnancy weight) are predetermined at conception and are not modifiable. Overall, less than 40% of macrosomic infants are born to women with identifiable risk factors.

In normal-weight women with gestational diabetes, 13.6% give birth to an LGA infant, while 22.3% of obese women with gestational diabetes give birth to LGA infants. Conversely, in diabetic women with good glycemic control, the rate of macrosomia approaches that of the general population (10%–13%). Even though the risk of accelerated fetal growth in infants of diabetic mothers increases with worsening hyperglycemia, there is no known universal threshold value of hyperglycemia that predisposes the fetus to macrosomia.

Poorly understood factors that relate to increased fetal growth include genetic predisposition, fetal intrauterine metabolism, and placental nutrient transport. Some or all of these factors likely contribute to the intrauterine environment and influence fetal growth. Fetal hyperinsulinism is an example of altered fetal metabolism that can lead to excessive intrauterine growth and an increased risk for type 2 diabetes in later life. However, fetal hyperinsulinism appears to affect only a minority of pregnancies complicated by diabetes and does not correlate well with maternal glycemic control. This lack of association between fetal hyperinsulinism and maternal glucose levels may explain why good glycemic control does not eliminate the risk of macrosomia in some diabetic pregnancies.

DIAGNOSIS OF MACROSOMIA

Available methods for diagnosis of macrosomia are ultrasound measurements, MRI measurements, clinical assessment via Leopold maneuvers or fundal height measurements, and maternal estimation. A comparison of these diagnostic techniques, including sensitivities and specificities, is provided in Table 2. Unfortunately,
Table 1
Risk factors associated with macrosomia

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
<th>Odds Ratio (OR)</th>
<th>Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal prepregnancy</td>
<td>Ethnicity</td>
<td>0.54–1.15</td>
<td>Bowers et al, 8 2013</td>
</tr>
<tr>
<td>characteristics</td>
<td>Height ≥80th percentile</td>
<td>1.71</td>
<td>Marshall et al, 9 2019</td>
</tr>
<tr>
<td></td>
<td>Own birth weight &gt;4000g</td>
<td>1.378</td>
<td>Su et al, 10 2016</td>
</tr>
<tr>
<td>Maternal comorbidities</td>
<td>Diabetes (pregestational)</td>
<td>6.97</td>
<td>Jolly et al, 11 2003</td>
</tr>
<tr>
<td></td>
<td>Diabetes (gestational)</td>
<td>1.48–2.77</td>
<td>Jolly et al, 11 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bowers et al, 6 2013</td>
</tr>
<tr>
<td></td>
<td>Hypertriglyceridemia</td>
<td>1.19</td>
<td>Jin et al, 12 2016</td>
</tr>
<tr>
<td></td>
<td>Obesity (body mass index [BMI] ≥30 kg/m²)</td>
<td>2.08–5.64</td>
<td>Jolly et al, 11 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Usta et al, 13 2017</td>
</tr>
<tr>
<td></td>
<td>Excessive gestational weight gain</td>
<td>1.55–5.45</td>
<td>Bowers et al, 8 2013</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Usta et al, 13 2017</td>
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<tr>
<td></td>
<td>Multiparity</td>
<td>1.31–2.20</td>
<td>Jolly et al, 11 2003</td>
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<td></td>
<td></td>
<td>Bowers et al, 8 2013</td>
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<td></td>
<td></td>
<td></td>
<td>Usta et al, 13 2017</td>
</tr>
<tr>
<td></td>
<td>Advanced maternal age</td>
<td>1.22–1.86</td>
<td>Bowers et al, 8 2013</td>
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<td></td>
<td></td>
<td></td>
<td>Jolly et al, 11 2003</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Usta et al, 13 2017</td>
</tr>
<tr>
<td>Fetal characteristics</td>
<td>Male fetus</td>
<td>1.89–2.0</td>
<td>Usta et al, 13 2017</td>
</tr>
<tr>
<td></td>
<td>Post-term (gestational age ≥42 weeks)</td>
<td>2.62</td>
<td>Sheiner et al, 14 2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maoz et al, 15 2019</td>
</tr>
<tr>
<td>Genetic syndromes</td>
<td>Beckwith Wiedemann</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Weaver</td>
<td></td>
<td>N/A</td>
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<td></td>
<td>Sotos</td>
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<td>N/A</td>
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<td></td>
<td>Perlman</td>
<td></td>
<td>N/A</td>
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<td></td>
<td>Costello</td>
<td></td>
<td>N/A</td>
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<td></td>
<td>Pallister-Killian</td>
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<td>N/A</td>
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Accurate detection of macrosomia prior to birth remains a clinical conundrum. Although accelerated fundal height growth may provide an early clinical clue for suspected macrosomia, fundal height measurements themselves are not reliable with birthweight greater than 4000 g. With birthweights between 2500 and 4000 g, good evidence demonstrates the superiority of ultrasound-derived fetal weight estimates over clinical estimation. However, all techniques lose accuracy as birthweight increases over 4000 g.

There are over 30 different formulas for ultrasound estimates of fetal weight, but most use the fetal biparietal diameter, head circumference, abdominal circumference, and femur length alone or in combination to estimate fetal weight. In studies comparing the most common formulas, Hadlock’s formula (which incorporates biparietal diameter, femur length, and abdominal circumference) produced the most accurate estimates of fetal weight, whereas Shepard’s formula (which incorporates only biparietal diameter and abdominal circumference) produced the least accurate estimates. Other formulas have been derived specifically for diabetic patients and specifically for patients with clinically suspected macrosomia. However, these formulas have not been shown to be useful in distinguishing macrosomic fetuses from normal-weight fetuses. Overall, ultrasound estimates of fetal weight have a low accuracy.
sensitivity (10%–45%), but a high specificity (57%–99%) and high negative predictive value (92%–99%) for detecting macrosomia. However, the American Institute of Ultrasound in Medicine reports that even the best fetal weight detection methods yield error rates of approximately 15%. Other reports show error rates as high as 38% in infants weighing over 4500 g.

When studied individually, abdominal circumference may be the most clinically useful biometric parameter in the sonographic evaluation for macrosomia, particularly in diabetic patients. Even when the overall estimated fetal weight is less than the 90th percentile, an abdominal circumference measuring greater than the 90th percentile or 2 to 3 weeks ahead of gestational age may be a sign of impending macrosomia. Some data suggest that if the abdominal circumference measures less than the 90th percentile on 2 consecutive ultrasounds, the likelihood of developing macrosomia is low. In 1 study, using large fetal abdominal circumference as a criterion for starting insulin in patients with gestational diabetes resulted in a reduction in birthweight.

Another ultrasound measurement that has been studied in the context of macrosomia is fetal soft tissue thickness. Measurements of the subcutaneous fat can be performed in multiple areas including the shoulder, midhumerus, abdominal wall, thigh, and buccal area. Initial studies show that soft tissue thickness may predict macrosomia and correlates well with skin fold measurements at birth. Increased soft tissue thickness and increased skin fold thickness are most commonly seen in pregnancies with poorly controlled diabetes. Although this technique has not been adopted widely in clinical practice, these initial studies are promising and warrant further investigation.

Other studies show that the ratio of head circumference (HC) to abdominal circumference (AC) in diabetic pregnancies may indicate disproportionate fetal growth. In fact, these earlier studies demonstrated that an HC/AC ratio of less than 0.80 suggested disproportionate central body growth and was associated with an increased risk for shoulder dystocia and birth trauma. However, more recent data show that the ultrasound-derived fetal abdominal diameter-biparietal diameter difference is not a reliable predictor of shoulder dystocia or brachial plexus injury.

In addition to ultrasonography, MRI is another imaging modality that may be used to estimate fetal weight. Recent studies found that MRI has a higher sensitivity and specificity than ultrasonography for detecting macrosomia. However, the clinical utility of MRI may be limited by cost, availability, and the inability to image some patients adequately because of maternal obesity or claustrophobia. In addition, ultrafast MRI

<table>
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<tr>
<th>Diagnostic Method</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Studies</th>
</tr>
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<tbody>
<tr>
<td>Fundal height measurement</td>
<td>20%–70%</td>
<td>&gt;90%</td>
<td>Persson et al,24 1986 Goetzinger et al, 23 2013</td>
</tr>
<tr>
<td>Ultrasound (for infants weighing &gt;4000 g)</td>
<td>10%–45%</td>
<td>57%–99%</td>
<td>Malin et al, 19 2016</td>
</tr>
<tr>
<td>Ultrasound (for infants weighing &gt;4500 g)</td>
<td>56%</td>
<td>92%</td>
<td>Malin et al, 19 2016</td>
</tr>
<tr>
<td>MRI</td>
<td>85%–93%</td>
<td>95%–97%</td>
<td>Malin et al, 19 2016 Kadji et al, 21 2019</td>
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</tbody>
</table>
protocols are needed to image a live mobile fetus floating in amniotic fluid. As technology and techniques are refined, fetal MRI may be used more regularly in clinical practice. Although promising, at this time, fetal MRI to detect macrosomia is considered investigational.

As noted previously, clinical estimates of fetal weight can also be achieved by abdominal palpation (Leopold maneuvers) and fundal height measurements. Some studies indicate that in experienced hands, clinical estimates approach the accuracy of ultrasound estimates for fetal weight. Other studies show that a mother’s estimate of her own baby’s weight can be as accurate as clinical or ultrasound estimates. In clinical practice, it is reasonable to use maternal and clinical estimates to estimate fetal weight, but in cases where macrosomia is suspected, ultrasound examination should be considered. Despite the inherent limitations of all available methods for fetal weight estimation, a combination of clinical estimates, ultrasound assessment, and clinical history can help craft an appropriate management plan when macrosomia is suspected.

**PREVENTION OF MACROSOMIA**

Overall, our ability to prevent macrosomia is limited, because many of the risk factors discussed are not modifiable. However, there are some strategies that can, at a minimum, mitigate the degree of macrosomia encountered. These include exercise, bariatric surgery for patients with class 2 or class 3 obesity, and appropriate glycemic control for diabetic patients.

There are multiple benefits of exercise during pregnancy including less weight gain, which is associated with lower risk of macrosomia or LGA infants, and lower risk of cesarean delivery. These benefits have been observed with both resistance training and aerobic exercise. Exercise has not been associated with an increased risk of preterm birth or small for gestational age (SGA) infants. In contrast, patients who undergo bariatric surgery are at increased risk of delivering SGA infants and possibly preterm birth. The degree of pregnancy risks and long-term weight-loss benefits of bariatric surgery vary depending on the type of procedure. When compared with adjustable gastric banding (AGB), Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG) are associated with more rapid weight loss in the immediate postoperative period, in addition to higher rates of excess weight loss at 10-year follow-up. Patients with RYGB or SG typically achieve optimal weight loss and weight stabilization by 1 year after surgery, as opposed to patients with AGB, who typically do not achieve these goals until 2 years after surgery; therefore, the recommended delay in conception after surgery is shorter for RYGB and SG than for AGB. However, RYGB and SG are associated with less gestational weight gain than AGB, and insufficient gestational weight gain in turn is strongly associated with adverse neonatal outcomes including low birth weight. Furthermore, patients with RYGB are at increased risk of developing internal herniation during pregnancy, while patients with AGB are at increased risk of gastric band slippage during pregnancy. For patients with class 2 or class 3 obesity, the aforementioned risks of bariatric surgical intervention must be weighed against the benefits of a lower likelihood of developing gestational diabetes and LGA infants.

In women with diabetes, diet therapy to control maternal hyperglycemia can decrease macrosomia by as much as 73%. In nondiabetic women, a low-glycemic diet may reduce excessive gestational weight gain; however, it is unclear whether diet alone reduces the risk of macrosomia in these patients. Thus, women who are at risk for developing macrosomia should be advised to exercise and (if they are diabetic) to maintain
euglycemia with an appropriate low glycemic diet. Furthermore, preconception counseling for patients with class 2 or class 3 obesity should include a discussion of the risks and benefits of bariatric surgery. If the patient elects to have bariatric surgery, it should be performed at least 6 months before a pregnancy is achieved.

**MANAGEMENT OF SUSPECTED MACROSOMIA**

Even though macrosomia is technically a statistical definition and not a true disease, the risk for potentially serious maternal, fetal, and neonatal morbidity mandates thoughtful management plans in patients with suspected macrosomia.

The clinical dilemma encountered most often by clinicians managing a patient with suspected macrosomia at term is whether or not to allow labor or to proceed with cesarean section. Here again, the effectiveness of prophylactic cesarean delivery in reducing fetal and neonatal morbidity in these cases has not been evaluated in randomized clinical trials. In addition, as outlined earlier, available techniques to estimate fetal weight in and of themselves are inaccurate. Finally, cesarean section reduces, but does not completely eliminate the risk for birth trauma and brachial plexus injury associated with vaginal birth. Thus, while clinically it may be tempting to select a route of delivery based solely on estimated fetal weight, such a decision should take into account all pertinent risk factors and the patient’s personal preferences and future reproductive plans as part of detailed informed consent. Patient counseling and shared decision making is warranted in these cases, and such counseling at a minimum should address several points:

- Accurate prediction of actual birthweight and/or shoulder dystocia antenatally is limited
- The incidence of shoulder dystocia and brachial plexus injuries is low even when macrosomia is present, and most macrosomic fetuses do not experience shoulder dystocia during vaginal delivery
- Brachial plexus injuries can occur even with cesarean delivery

Thus, vaginal delivery can be a reasonable plan in patients with suspected macrosomia but only after appropriate informed consent. Although a trial of labor after cesarean (TOLAC) is not contraindicated for patients with suspected macrosomia, these patients should be counseled on the increased risk of uterine rupture and the decreased likelihood of a successful vaginal birth after cesarean (VBAC). Current guidelines from ACOG do not support a planned cesarean delivery unless estimated fetal weight exceeds 4500 g in diabetic women or 5000 g in nondiabetic women. These are broad guidelines, however, and care must be individualized and based on informed consent and clinical judgment. The benefits of induction of labor as opposed to expectant management for suspected macrosomia are uncertain, especially prior to 39 weeks gestation. Some studies have shown that induction of labor for suspected macrosomia at any gestational age increases the risk of cesarean delivery but does not reduce shoulder dystocia or neonatal morbidity. Other studies, some of which included patients induced prior to 39 weeks gestation, have shown that induction of labor was not associated with a lower risk of shoulder dystocia and was possibly associated with a slightly lower risk of cesarean delivery. Further studies are needed to clarify the optimal timing for delivery of infants with suspected macrosomia and whether induction of labor improves outcomes in such cases. At present, induction at 39 weeks for suspected macrosomia (or electively) is reasonable in cases with appropriate informed consent and shared decision making. Induction prior to 39 weeks is not as well supported by the current literature.
but may still be considered carefully in select cases, especially if there are other maternal comorbidities such as poorly controlled diabetes.

If a patient with macrosomia has been appropriately counseled and desires to attempt a trial of labor, careful intrapartum monitoring of the labor curve and fetal heart tracing are required. The obstetrician should anticipate and be prepared for the possibility of postpartum hemorrhage and shoulder dystocia at the time of delivery. Uterotonic medications (eg, oxytocin, methylergonovine, 15-methyl prostaglandin F$_{2\alpha}$, and misoprostol), tranexamic acid, and an intrauterine balloon tamponade should be available at bedside in case the patient experiences heavy bleeding because of uterine atony. The obstetrician should also consider obtaining a type and crossmatch at the time of admission to have appropriate blood products available for a possible transfusion, especially if the patient is anemic. Furthermore, the obstetrician should ensure that other staff members are available and qualified to assist in case of shoulder dystocia. Shoulder dystocia simulations and team-based drills effectively improve communication and utilization of obstetric maneuvers while potentially reducing the risk of transient brachial plexus injuries.$^{79,80}$

Operative vaginal delivery, especially midpelvic procedures, increase the risk of shoulder dystocia and brachial plexus injury and should be used with extreme caution in patients with suspected macrosomia. The risk is even higher in patients with suspected macrosomia and a prolonged second stage of labor or arrest of descent.$^{81}$ In these circumstances, cesarean delivery is preferable. At a minimum, extensive informed consent is required prior to attempting operative vaginal delivery in patients with suspected macrosomia. Such counseling should address not only the increased risk of shoulder dystocia and brachial plexus injury, but also the increased risk of third- or fourth-degree perineal lacerations (which themselves lead to hemorrhage, pain, dyspareunia, and fecal incontinence).

MANAGEMENT OF SHOULDER DYSTOCIA

Shoulder dystocia occurs in 0.15% to 2.0% of all vaginal deliveries, but the incidence is as high as 14% when the birthweight exceeds 4500 g.$^7$ Once a shoulder dystocia is encountered, standardized maneuvers usually relieve the impaction and accomplish delivery. These include, but are not limited to, McRobert maneuver, suprapubic pressure, delivery of the posterior arm, and rotational maneuvers (Rubin and Wood). Although no randomized controlled trials have demonstrated the superior efficacy of one maneuver over another, it is reasonable to begin with McRobert maneuver, because it is relatively simple and will resolve the shoulder dystocia in about 40% of cases.$^{82}$ Addition of suprapubic pressure will resolve about 60% of shoulder dystocia cases, and three maneuvers will resolve 95% of cases.$^{82}$ If all these maneuvers are unsuccessful, Gaskin all-fours maneuver (positioning the patient on her hands and knees and applying downward traction on the posterior shoulder) and episiotomy may be employed. Then, if still unsuccessful, the maneuvers can be repeated. In extreme cases where the shoulder dystocia is not alleviated after the aforementioned techniques have been exhausted, heroic measures such as intentional clavicular fracture (which involves pulling the anterior clavicle outward to decrease the bisacromial diameter) and Zavanelli maneuver (which involves pushing the fetal head back into the vagina in preparation for cesarean delivery) can be performed as a last resort. Intentional clavicular fracture is technically challenging and may cause injury to underlying vascular and pulmonary structures, but it is less morbid than the Zavanelli maneuver.$^{83}$

Although shoulder dystocia can result in neonatal brachial plexus palsy and clavicle fracture, these outcomes are uncommon, and most cases resolve without permanent
sequelae. Brachial plexus palsies (both transient and permanent) affect 1.5 per 1000 total births, while clavicle fractures affect 0.4% to 0.6% of all births and can occur in women with and without shoulder dystocia. However, fetal macrosomia increases the risk for brachial plexus palsy. In women with a history of shoulder dystocia in a prior pregnancy, cesarean section should be recommended, as the risk of recurrent shoulder dystocia can be as high as 17%.

SUMMARY

Macrosomia results from abnormal fetal growth and can lead to serious consequences for both the mother and fetus. From a practical perspective, most known risk factors are not easily modifiable. Techniques to diagnose macrosomia include ultrasound examination, clinical estimation, maternal estimation, and MRI. The ability to accurately predict birthweight remains limited, and all techniques have an error rate of 15% to 20% or higher, especially as birthweight increases. In cases of suspected macrosomia, patients must be counseled carefully regarding a delivery plan, and cesarean section should be considered when indicated. Although induction for suspected macrosomia typically is not advisable before 39 weeks gestation, it may be considered in select cases after shared decision-making and with careful informed consent. In all deliveries with suspected macrosomia, extreme caution is advised with regard to operative vaginal delivery. Although shoulder dystocia can occur in any vaginal delivery, increasing birthweight is associated with a higher incidence of shoulder dystocia and concomitant brachial plexus injury, and these factors must be weighed carefully in devising an appropriate delivery plan.

CLINICS CARE POINTS

- Ultrasound assessment may be the most clinically useful method to assess for macrosomia, particularly in diabetic patients.
- Some strategies that can mitigate the degree of macrosomia include exercise, bariatric surgery for patients with class 2 or class 3 obesity, and appropriate glycemic control for diabetic patients.
- Cesarean delivery is recommended when the estimated fetal weight is 4500 g in diabetic patients or 5000 g in nondiabetic patients.
- For patients with macrosomia, induction of labor may be considered on an individualized basis and only with appropriate informed consent.
- Women with suspected macrosomia are at increased risk for postpartum hemorrhage and shoulder dystocia at the time of delivery.

DISCLOSURE

The authors have nothing to disclose.

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