The American College of Obstetricians and Gynecologists
WOMEN'S HEALTH CARE PHYSICIANS

PRACTICE BULLETIN

CLINICAL MANAGEMENT GUIDELINES FOR OBSTETRICIAN–GYNECOLOGISTS

NUMBER 173, NOVEMBER 2016

(Replaces Practice Bulletin Number 22, November 2000)

Fetal Macrosomia

Suspected fetal macrosomia is encountered commonly in obstetric practice. As birth weight increases, the likelihood of labor abnormalities, shoulder dystocia, birth trauma, and permanent injury to the neonate increases. The purpose of this document is to quantify those risks, address the accuracy and limitations of methods for estimating fetal weight, and suggest clinical management for a pregnancy with suspected fetal macrosomia.

Background

Definition

Two terms are applied to excessive fetal growth: 1) large for gestational age and 2) macrosomia. The term "large for gestational age" generally implies a birth weight equal to or greater than the 90th percentile for a given gestational age. The term fetal macrosomia implies growth beyond an absolute birth weight, historically 4,000 g or 4,500 g, regardless of the gestational age, although establishing a universally accepted definition for macrosomia has been challenging. For years, clinicians have relied on popular birth weight curves to identify weight cutoffs for the 90th percentile for a given gestational age (1–3). A revised national reference for neonatal birth weight is now available. A study using the 2011 U.S. Live Birth File of the National Center for Health Statistics reported data for birth weight references based on the best obstetric estimate of gestational age for more than 3.2 million births (4). The 50th, 90th, and 95th percentiles for birth weight from 37 completed weeks to 42 completed weeks of gestation are shown in Table 1.

Although the risk of morbidity for infants and women when birth weight is between 4,000 g and 4,500 g is greater than that of the general obstetric population, it increases sharply when the birth weight is more than 4,500 g (5–7). A large cohort study of 8.3 million births in the National Center for Health Statistics analyzed live-birth and infant death files for the United States and demonstrated that labor abnormalities and newborn complications (eg, a 5-minute Apgar score of less than 4, assisted ventilation longer than 30 minutes, birth

Table 1. Birth Weight Percentiles for Gestational Age: U.S. 2011 Single Live Births to Resident Women Between 37 Completed Weeks and 42 Completed Weeks of Pregnancy (Based on Best Obstetric Estimate of Gestational Age) ⇦

	Birth Weight (g)		
Gestational Age (Weeks)	50th Percentile	90th Percentile	95th Percentile
37	3,025	3,612	3,818
38	3,219	3,799	3,995
39	3,374	3,941	4,125
40	3,499	4,057	4,232
41	3,600	4,167	4,340
42	3,686	4,290	4,474

Modified from Duryea EL, Hawkins JS, McIntire DD, Casey BM, Leveno KJ. A revised birth weight reference for the United States. Obstet Gynecol 2014; 124:16–22.

Committee on Practice Bulletins—Obstetrics. This Practice Bulletin was developed by the American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Obstetrics in collaboration with William H. Barth Jr, MD.

The information is designed to aid practitioners in making decisions about appropriate obstetric and gynecologic care. These guidelines should not be construed as dictating an exclusive course of treatment or procedure. Variations in practice may be warranted based on the needs of the individual patient, resources, and limitations unique to the institution or type of practice.

injuries) increase within birth weight category 4,000–4,499 g, newborn morbidity increases significantly within birth weight category 4,500–4,999 g, and newborn mortality increases significantly with birth weights greater than 5,000 g (Fig. 1) (8). In another cohort study based on 6 million U.S.-linked stillbirths, live-birth and infant death records demonstrated remarkably similar findings; perinatal outcomes were no different in the group weighing 4,000–4,499 g compared with those weighing less than 4,000 g, but morbidity and mortality, including stillbirth, increased significantly in those weighing 4,500 g or greater and dramatically in those weighing 5,000 g or greater (9). Recent reports suggest that customized growth curves using ultrasound-estimated fetal weights based on ethnicity or individual characteristics may improve precision in evaluating fetal growth (10) and that customized classification of large-for-gestational-age fetuses may better define a particular birth weight associated with increased maternal and neonatal morbidity and mortality (11, 12). However, neither of these methods is clearly superior to the large, population-based reports (13). At this time, it seems reasonable to recognize a continuum of risk and to divide macrosomia into three categories:

1. Birth weight of 4,000–4,499 g with increased risk of labor abnormalities and newborn complications
2. Birth weight of 4,500–4,999 g with additional risk of maternal and newborn morbidity
3. Birth weight of 5,000 g or greater with additional risk of stillbirth and neonatal mortality

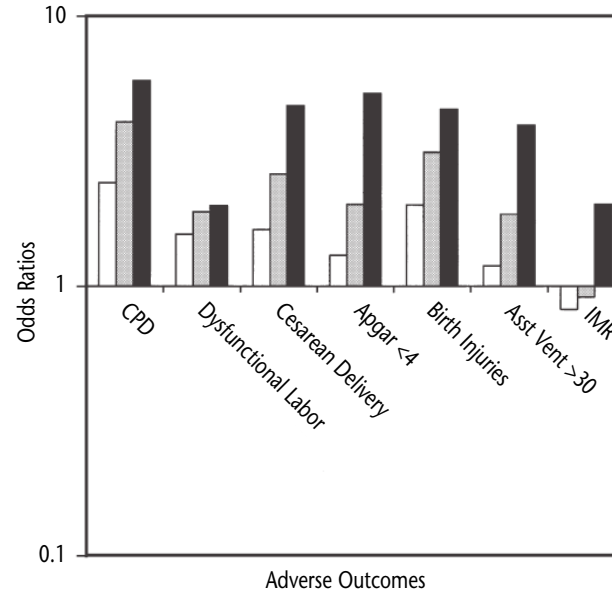

Figure 1. Increased risk of adverse outcomes by macrosomia category. *Open bars,* Category 1 (4,000–4,499 g); *gray bars,* category 2 (4,500–4,999 g); *black bars,* category 3 (5,000 g or greater). The reference group is 3,000 g to 3,999 g. All bars greater than an odds ratio of 1 are significant at $P<.05$. Abbreviations: Apgar <4, Apgar score less than 4 at 5 minutes of life; Asst Vent >30, assisted ventilation greater than 30 minutes; CPD, cephalopelvic disproportion; IMR, infant mortality rate. (Boulet SL, Alexander GR, Salihu HM, Pass M. Macrosomic births in the United States: determinants, outcomes, and proposed grades of risk. Am J Obstet Gynecol 2003;188:1372–8.) ⇦

Frequency of Occurrence

Data from the National Center for Health Statistics show that 8% of all live-born infants in the United States weigh 4,000 g or more (14). Only 1.1% weigh more than 4,500 g. The most serious complication of fetal macrosomia is shoulder dystocia, but the risk of occurrence is low, complicating only 0.2–3.0% of all vaginal deliveries (15). When birth weight is at least 4,500 g, however, the risk of shoulder dystocia is increased, with rates reported from 9% to 14% (7, 16, 17). In the presence of maternal diabetes, birth weight of 4,500 g or greater has been associated with rates of shoulder dystocia from 20% to 50% (7, 17). Figure 2 shows the relationship between birth weight, maternal diabetes status, spontaneous or assisted vaginal delivery, and the mean frequency of shoulder dystocia based on a study of more than 175,000 deliveries in California in 1992 (7).

The American College of Obstetricians and Gynecologists (the College) defines the diagnosis of *shoulder dystocia* as a failure of delivery of the fetal shoulder(s) after initial attempts at downward traction, which requires additional maneuvers to effect delivery (18). Several issues complicate attempts to define precisely the incidence of shoulder dystocia among macrosomic infants. First, the extent of reporting by clinicians is variable (15, 19). Second, the incidence of shoulder dystocia and the likelihood of subsequent fetal injury vary depending on the criteria used to assign a diagnosis of dystocia (20). Studies relying on definitions similar to the College definition (21) report a lower overall incidence of shoulder dystocia (but greater proportional fetal morbidity) than studies with less precise definitions (16). Finally, although macrosomia clearly increases risk, most instances of shoulder dystocia occur unpredictably among infants of normal birth weight (22).

Risk Factors for Macrosomia

A variety of factors predispose a newborn to macrosomia, including preexisting maternal diabetes, uncontrolled gestational diabetes, maternal prepregnancy obesity, excessive gestational weight gain, maternal interpregnancy weight gain, a prior macrosomic infant, postterm pregnancy, and

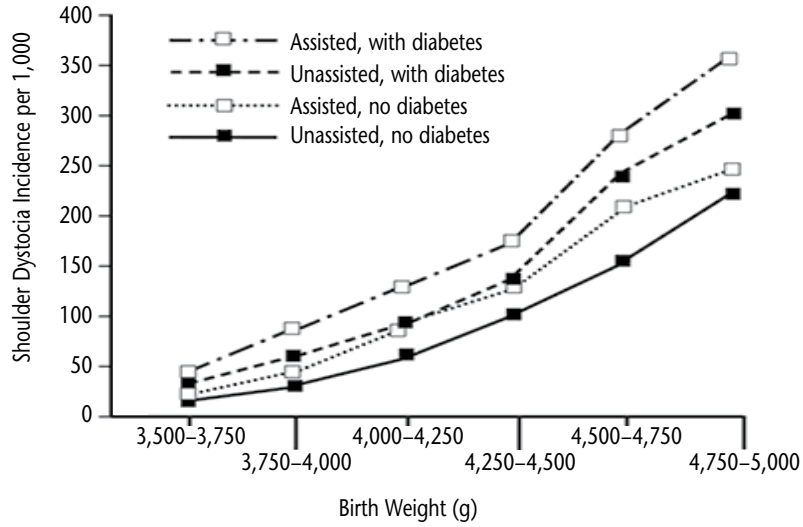

Figure 2. Frequency of shoulder dystocia for increasing birth weight by maternal diabetes status and method of vaginal delivery—spontaneous or assisted. (Nesbitt TS, Gilbert WM, Herrchen B. Shoulder dystocia and associated risk factors with macrosomic infants born in California. Am J Obstet Gynecol 1998;179:476–80.) ⇦

maternal nonsmoking status (8, 23–27). The interplay of these risk factors is complex and varies by prepregnancy body mass index, race, and ethnicity (23, 28, 29). A large case–control study examined the relative contributions of proposed risk factors for macrosomia, excluding preexisting diabetes (30). In decreasing order of importance, these risk factors included a prior history of macrosomia, maternal prepregnancy weight, weight gain during pregnancy, multiparity, male fetus, gestational age greater than 40 weeks, ethnicity, maternal birth weight, maternal height, maternal age younger than 17 years, and a positive 50-g glucose screen with a negative result on the 3-hour glucose tolerance test.

Pregestational diabetes and gestational diabetes are associated with fetal macrosomia. Observational cohort studies demonstrate that graded increases in maternal glucose levels are associated with increases in newborn birth weight (31, 32). A study reported that 6% of women with untreated borderline gestational diabetes gave birth to infants exceeding 4,500 g, compared with only 2% of women with normal blood glucose tolerance (33). If gestational diabetes is unrecognized and untreated, the risk of macrosomia may be as high as 19% (34).

Anthropometric studies suggest that the macrosomia produced by maternal glucose intolerance is different from macrosomia associated with other predisposing factors (35, 36). Infants who are macrosomic because of maternal glucose intolerance tend to have greater total body fat, greater shoulder and upper-extremity circumferences, greater upper-extremity skin-fold measurements, and smaller head-to-abdominal-circumference ratios compared with macrosomic infants of women without diabetes. It has been suggested that it is this altered fetal body shape that is responsible for the higher incidence of shoulder dystocia seen among infants of women with diabetes (36). Regardless of birth weight, infants of women with diabetes have an increased risk of shoulder dystocia, clavicular fracture, and brachial plexus injury (7, 21, 37).

The relative contributions of maternal diabetes and obesity to fetal macrosomia remain controversial. One study reported that the risk of fetal macrosomia associated with unrecognized gestational diabetes persisted after controlling for maternal body mass index and maternal weight gain (34). In a study among women with diet-controlled gestational diabetes, adjusting for maternal weight decreased the relative risk of large infants (size greater than the 90th percentile) from 2.5 to 1.5 (38). Although diabetes and obesity increase the risk of fetal macrosomia, because of the increasing prevalence and relative frequency of maternal obesity compared with diabetes, maternal obesity plays a greater role in macrosomia at a population level (6, 23, 30).

The interaction of maternal weight, weight gain during pregnancy, and newborn macrosomia is complex. There is little doubt that birth weight, in general, increases with maternal body mass index (23, 25, 26). Although obese women are more likely than women of normal weight to have large infants, several issues confound this observation (23, 25, 26, 39). First, obese women are more likely to have diabetes mellitus (39). Second, excess weight gain during pregnancy is itself a risk factor for excessive fetal growth (25, 40), and the risk of newborn macrosomia associated with excessive

maternal weight gain is greater for obese than for nonobese women (25, 26, 39).

Gestational age influences birth weight and the risk of macrosomia. Among all races in the United States, the risk of macrosomia increases from 1.3% at 39–40 weeks of gestation to approximately 2.0% when gestational age exceeds 41 weeks (14).

A number of maternal historic factors and habits also influence infant birth weight. A woman who previously has given birth to an infant weighing more than 4,000 g is 5–10 times more likely to deliver an infant weighing more than 4,500 g than a woman without such a history (5, 30, 41). To a degree, maternal birth weight may predict newborn weight. Women whose own birth weight exceeded 8 lbs (approximately 3,600 g) are twice as likely to deliver infants weighing more than 4,000 g than are women whose birth weight was between 6 lb and 7.9 lb (approximately 2,700–3,500 g) (42). Finally, two cohort studies show that multiparity and grand multiparity (five or more deliveries) increase the risk of macrosomia (9, 41).

Genetic, racial, and ethnic factors also influence birth weight and the risk of macrosomia. Male infants typically weigh more than female infants at any gestational age and, therefore, constitute a greater proportion of infants with birth weights exceeding 4,500 g (9, 17). The risk of macrosomia varies with race and ethnicity as well (29). Genetic factors such as parental phenotype, race, and ethnicity play a role in determining newborn birth weight, but these factors interact in a complex manner with environmental factors during pregnancy (29, 43).

Diagnosis

An accurate diagnosis of macrosomia can be made only by weighing the newborn after delivery. The prenatal diagnosis of fetal macrosomia is imprecise. Methods used to predict birth weight include assessment of maternal risk factors, clinical examination, and ultrasound measurement of the fetus. Although ultrasonography enables the direct measurement of various fetal body parts, its accuracy in predicting macrosomia has been imprecise (44, 45). Although significant differences in fetal growth by self-identified maternal race and ethnicity among low-risk women have been demonstrated (10), longitudinal ultrasound examinations and individual growth-curve modeling do not appear to improve the detection of fetal macrosomia (46). The use of customized growth curves to detect fetal overgrowth and its complications has proved to be no better than the use of population-based growth curves (47). Studies comparing the accuracy of ultrasonography with that of physical examination for the detection of macrosomia also have been inconsistent, and none have proved that ultrasonography is superior to physical examination in a clinically meaningful way (48, 49). Indeed, parous women appear to be able to predict the weight of their newborns as well as clinicians who use ultrasound measurements or clinical palpation maneuvers (50, 51).

Risks Associated With Macrosomia

Maternal Morbidity

The primary maternal risk associated with macrosomia is an increased risk of cesarean delivery. Studies show that with birth weights greater than 4,500 g, the risk of cesarean delivery for women attempting a vaginal delivery is at least double that of controls (5, 6). Almost all of the increased risk is attributed to labor abnormalities (5, 16). Not surprisingly, studies have consistently demonstrated that the inaccurate ultrasound prediction of macrosomia predisposes women to the diagnosis of labor abnormalities and cesarean delivery independent of actual birth weight (52–54). One group reported that, as an indication for cesarean delivery, fetal macrosomia was responsible for 10% of the overall increase in cesarean delivery rates over the 7-year study period despite no change in the true rate of newborn macrosomia during that time (55).

The risks of postpartum hemorrhage and significant vaginal lacerations are elevated with macrosomia. A case–control study of risk factors for major obstetric hemorrhage (estimated blood loss greater than 1 liter) reported that a birth weight greater than 4,000 g increased the risk of significant maternal blood loss (odds ratio [OR], 1.9; 95% confidence interval [CI], 1.38–2.6) (56). The risk of third-degree and fourth-degree lacerations is increased twofold to threefold with macrosomia (17, 57, 58); this is especially true if delivery is complicated by shoulder dystocia (59).

Fetal Morbidity and Mortality

The fetal injuries most commonly associated with macrosomia and shoulder dystocia are fracture of the clavicle and damage to the nerves of the brachial plexus, specifically C5 and C6, which can produce Erb–Duchenne paralysis. Fracture of the clavicle complicates 0.4–0.6% of all deliveries and usually resolves without permanent sequelae (60, 61). For macrosomic infants, the risk of clavicular fracture is increased approximately 10-fold (61).

The risk of brachial plexus injury is low, with an incidence among all vaginal deliveries in the United States of approximately 1.5% (22). Case–control studies demonstrate that the risk of brachial plexus injury among infants delivered vaginally is increased 18-fold to 21-fold when birth weight exceeds 4,500 g (37, 61, 62). For

macrosomic infants delivered vaginally, reports place the occurrence of brachial plexus injury between 2.6% and 7% (63, 64). Even though shoulder dystocia has variation in the reported incidence (19), the occurrence of brachial plexus injury in the absence of documented shoulder dystocia is well described (7). Brachial plexus injury can occur with cesarean delivery (22). As with clavicular fracture, most brachial plexus injuries resolve without permanent disability. Among 59 confirmed brachial plexus injuries described in the Collaborative Perinatal Project, only six were still evident by age 4 months (65). By age 2 years, all but four had resolved. Other large case series confirm that 80–90% of brachial plexus injuries will resolve by age 1 year (66, 67). Persistent injury is more common with higher birth weights, and birth weights greater than 4,500 g in particular (68, 69).

Macrosomia is associated with a number of other risks to the newborn. These infants face an increased risk of depressed 5-minute Apgar scores and increased rates of admission and prolonged admission (greater than 3 days) to a neonatal intensive care unit (63, 70). It is not clear whether most of this risk is the result of complications of the birth process or an increased risk of nonreassuring status during labor (5, 70). Macrosomic newborns are more likely to be overweight and obese later in life than normal-weight newborns (71, 72).

Clinical Considerations and Recommendations

▶ *How accurate are clinical estimates of fetal weight?*

The diagnosis of fetal macrosomia is imprecise. For suspected fetal macrosomia, the accuracy of estimated fetal weight using ultrasound biometry is no better than that obtained with clinical palpation. The principal method of clinical estimation of fetal weight is by abdominal palpation. In several prospective studies, clinical palpation alone, irrespective of the level of clinical training of the obstetric care provider, predicted fetal macrosomia as accurately as any reported ultrasound method using either traditional formulas for estimated fetal weight or the addition of fetal soft tissue markers (73–76).

Measurement of the symphysis–fundal height alone is a poor predictor of fetal macrosomia. Although fundal height measurement has a greater sensitivity for fetuses exceeding 4,500 g, the utility of this measurement alone is questionable (77). Retrospective studies suggest that the sensitivity of fundal height measurement alone for the detection of macrosomia is well below 50% (77) and incorporating abdominal palpation maneuvers does not improve accuracy (78, 79). The effect of maternal obesity on the accuracy of clinical estimates of fetal weight is unclear, but most studies suggest a tendency to overestimate fetal weight when pregnancy is complicated by maternal obesity (79, 80). Prospective studies designed to evaluate abdominal palpation maneuvers with fundal height measurement for the detection of macrosomia report sensitivities of 10–43%, specificities of 99.0–99.8%, and positive predictive values between 28% and 53% (48, 81). Ultrasound measurements of those women with suspected fetal macrosomia on the basis of clinical examination alone decreased sensitivity and positive predictive value without measurably affecting specificity (81). Prospective studies among women with diabetes also have shown that clinical estimates of macrosomia are as predictive as those derived with ultrasonography (82).

Simply asking a parous woman for her estimate of the fetal weight may provide an estimate as accurate as any other. In two studies, a parous woman's ability to predict birth weight greater than 4,000 g was as accurate as that of clinicians using clinical palpation maneuvers alone (50, 51).

▶ *How accurate is ultrasound measurement in determining fetal weight?*

Ultrasonography-derived estimates of fetal weight are obtained by entering the measurements of various fetal body parts, usually including the abdominal circumference, into one of several popular regression equations (83, 84). Most commercially available ultrasound units have one or more of these equations already programmed into the system's software, allowing immediate calculation of estimated fetal weight. However, most of the regression formulas currently in use are associated with significant errors when the fetus is macrosomic. For example, the Hadlock formula to predict fetal weight has a mean absolute percent error of 13% for infants greater than 4,500 g, compared with 8% for nonmacrosomic infants (85).

Ultrasonography is poor at identifying the infant with a birth weight over 4,500 g. Among women without diabetes, ultrasound biometry used to detect macrosomia has a sensitivity of 22–44%, a specificity of 99%, a positive predictive value of 30–44%, and a negative predictive value of 97–99% (86, 87). Reports demonstrating greater accuracy generally rely on less stringent criteria for macrosomia, such as birth weight greater than 4,000 g or weight exceeding the 90th percentile for a given gestational age (88). However, when birth weight exceeds 4,500 g, only 50% of fetuses weigh within 10% of the

ultrasonography-derived estimate (89). Using existing formulas, an estimated fetal weight would have to exceed 4,800 g for the fetus to have more than a 50% chance of being macrosomic (86, 90). These observations suggest that the usefulness of ultrasonography for obtaining estimated weights is limited, and these limitations are neither operator dependent nor equipment dependent (89).

Similarly, no one formula based on ultrasound biometry performs significantly better than others for the detection of macrosomia over 4,500 g. One study compared the accuracy of 36 different published formulae for estimating fetal weight with ultrasonography, and none was superior to the others in a clinically meaningful way (91). In this study, the sensitivity of ultrasonography for the detection of birth weight over 4,500 g was only 22%, and the false positive rate was 7%. Ultrasound estimates based on three or four biometric parameters tend to perform better than estimates based on the abdominal circumference alone (92). However, for suspected fetal macrosomia, the accuracy of estimated fetal weight using ultrasound biometry is no better than that obtained with clinical palpation maneuvers.

As aforementioned, reports have shown that ultrasound estimation of fetal macrosomia predisposes women to the diagnosis of labor abnormalities and cesarean delivery independent of actual birth weight. As with clinical estimates of fetal weight, the true value of ultrasonography in the management of expected fetal macrosomia may be its ability to rule out the diagnosis, which may help to avoid maternal morbidity. A randomized controlled trial comparing women who received routine ultrasound examinations at 18 weeks of gestation and an additional ultrasound examination at 33 weeks of gestation with women who received a single routine ultrasound examination at 18 weeks demonstrated a slight reduction in induction of labor and elective cesarean delivery for suspected fetal macrosomia (93). However, this study failed to demonstrate any significant differences in perinatal outcomes.

▶ *Are there effective interventions for treating or preventing suspected fetal macrosomia?*

For women without diabetes, there are no proven interventions to treat suspected macrosomia. Despite the aforementioned well-known associations between maternal weight gain and macrosomia, randomized trials of diet with lifestyle modification (94) and of exercise (95) failed to demonstrate significant differences in the rates of large-for-gestational-age infants. A recent randomized clinical trial of supervised aerobic exercise for 1 hour 3 days a week from 9–11 weeks of gestation to near term demonstrated a slight reduction in newborns with birth weights of more than 4,000 g (96). Women who did not exercise had a 4.7% risk of infant birth weight over 4,000 g compared with 1.8% in the exercise group (OR, 2.5; 95% CI, 1.03–6.20; $P=.04$). These results suggest that moderate levels of exercise initiated in the first trimester of pregnancy could prevent macrosomia, but additional trials are needed.

For pregnancies that are complicated by diabetes mellitus, control of maternal hyperglycemia clearly decreases the risk of fetal macrosomia. One clinical trial suggests that the addition of insulin to diet therapy may treat early macrosomia diagnosed between 29 weeks and 33 weeks of gestation (97). This study randomized 98 women with gestational diabetes and a fetal abdominal circumference exceeding the 75th percentile for gestational age to either diet therapy alone or diet therapy with twice-daily insulin. The addition of insulin therapy decreased the likelihood of birth weight greater than the 90th percentile from 45% among those treated with diet only to 13% among those receiving insulin ($P<.01$) (97). These results are consistent with larger trials designed to determine the effects of treatment of mild gestational diabetes on newborn outcomes. In the Australian Carbohydrate Intolerance Study in Pregnant Women trial, the risk of a birth weight greater than 4,000 g was reduced from 21% to 10% (relative risk [RR], 0.47; 95% CI, 0.34–0.64; $P=.001$) (98). Similarly, in a large multicenter randomized trial of the treatment of mild gestational diabetes, the risk of a birth weight greater than 4,000 g was reduced from 14.3% to 5.9% (RR, 0.41; 95% CI, 0.26–0.66; $P=.001$) (99). Together, these trials confirm that control of maternal hyperglycemia is important in the prevention of macrosomia among women who have been diagnosed with gestational diabetes.

▶ *When should cesarean delivery be considered for suspected macrosomia at a particular estimated fetal weight?*

Although the diagnosis of fetal macrosomia is imprecise, prophylactic cesarean delivery may be considered for suspected fetal macrosomia with an estimated fetal weight of at least 5,000 g in women without diabetes and at least 4,500 g in women with diabetes. However, planned cesarean delivery for suspected fetal macrosomia is controversial. Cesarean delivery reduces but does not eliminate the risk of birth trauma and brachial plexus injury associated with fetal macrosomia (6, 37, 100). The clinical effectiveness of offering prophylactic cesarean delivery to women with any specific estimated fetal weight has not been established in randomized clinical trials. To date, only one observational study has evaluated a policy of using ultrasonography-derived fetal

weight estimates to determine the route of delivery (101). In this study, 1,337 women with diabetes were offered scheduled cesarean delivery based on ultrasonography-derived fetal weight estimates greater than 4,250 g and induction of labor if ultrasound measurements resulted in a prediction of a large-for-gestational-age infant with an estimated fetal weight less than 4,250 g (101). The study cohort was compared with a historic control group of 1,227 women with diabetes who were managed without intervention for accelerated fetal growth during the 3 years preceding implementation of the study protocol. The overall incidence of shoulder dystocia was 2.8% during the control period and 1.5% after implementation of the study protocol (OR, 1.9; 95% CI, 1.0–3.5). A significant increase in the institutional cesarean delivery rate from 21.7% in the control group to 25.1% in the intervention group ($P<.04$) was reported, with nearly one half (47%) of the infants delivered by scheduled cesarean delivery for ultrasonography-derived fetal weight estimates of at least 4,250 g having a birth weight of less than 4,000 g. Although the sample size was insufficient for comparison, the risk of birth trauma was not eliminated (two versus one brachial plexus injury and 10 versus six fractures in the control versus study cohort, respectively). The use of historic controls, the nonrandomized design of the study, the use of multiple interventions, and the small sample size severely limit the usefulness of the conclusions from the study.

Large cohort and case–control studies demonstrate the safety of allowing a trial of labor for estimated birth weights of more than 4,000 g (17, 102). Among a group of 2,924 infants with birth weights of at least 4,000 g, 48 injuries (1.6%) were noted. Among the 22 brachial plexus injuries with documented follow-up, five were clinically evident at 6 months (69). A second study reported 27 occurrences (11.4%) of shoulder dystocia and three instances (1.3%) of brachial plexus injury in a group of 236 neonates weighing at least 4,200 g (103). In an additional series of 87 infants with birth weights greater than 4,500 g who were delivered vaginally, investigators reported five cases (5.7%) of Erb–Duchenne palsy. By 3 months of age, all affected infants were without evidence of brachial plexus paralysis (102). A fourth study reported that among 157 infants delivered vaginally with birth weights greater than 4,500 g, no permanent sequelae were identified by age 2 months (17). The risk of short-term morbidity associated with vaginal delivery in this group is low, and that of permanent injury is even lower. Pregnant women with suspected fetal macrosomia should be provided individualized counseling about the risks and benefits of vaginal and cesarean delivery based on the degree of macrosomia.

Despite the poor predictive value of an estimated fetal weight of more than 5,000 g and a lack of evidence supporting cesarean delivery at any estimated fetal weight, most, but not all, authors agree that consideration should be given to cesarean delivery in this situation (6, 63, 102). With an estimated fetal weight of greater than 4,500 g, a prolonged second stage of labor or arrest of descent in the second stage is an indication for cesarean delivery. Among all infants with birth weights exceeding 5,000 g, there are reports of cesarean delivery rates of 35–60%, brachial plexus injury rates of 7–11%, and a neonatal death rate as high as 1.9% (6, 8, 63, 102). In contrast, despite reporting a 7% absolute rate of brachial plexus injury among vaginally delivered infants weighing more than 5,000 g, some investigators suggest that ultrasonography-derived fetal weight estimates alone should not be used to determine the route of delivery because of the poor accuracy of ultrasonography for determining prenatally if this threshold has been exceeded (37, 45).

▶ *Is there a role for induction of labor in the management of term patients with suspected fetal macrosomia?*

Suspected fetal macrosomia is not an indication for induction of labor because induction does not improve maternal or fetal outcomes. Evidence from retrospective cohort studies examining a policy of induction of labor in term patients with suspected fetal macrosomia is inconsistent. Some reports show that induction of labor increases the risk of cesarean delivery without reducing shoulder dystocia or newborn morbidity (104–106). Others suggest a slight decrease or no effect on the risk of cesarean delivery and no difference in the rate of shoulder dystocia with induction of labor (107, 108). Some of these studies are limited by sample size and all are compromised because of possible bias introduced by their retrospective nature.

Two randomized clinical trials have examined the effect of a policy of induction of labor at term for ultrasonography-estimated fetal weight greater than the 90th percentile. In the first trial, a total of 273 women at 38 weeks of gestation or later with ultrasonography-derived estimated fetal weights between 4,000 g and 4,500 g were randomized to either planned induction of labor or expectant management (109). The cesarean delivery rates were similar: 19.4% for the induction group and 21.6% for the expectant group. There were 11 cases of shoulder dystocia: five in the induction group and six in the expectant group. All were managed without brachial plexus injury or other trauma. In a second European trial, a total of 822 women with estimated fetal

weights above the 95th percentile for gestational age at 37 weeks to 38 weeks of gestation were randomized to induction of labor within 3 days or to expectant management (110). With induction of labor, the risk of shoulder dystocia was reduced from 4% to 1% (RR, 0.32; 95% CI, 0.12–0.85). Importantly, there were no instances of brachial plexus injury in either group, and the cesarean delivery rates were similar: 28% in the induction group and 32% in the expectant management group (RR, 0.89; 95% CI, 0.72–1.09). The only significant difference in newborn outcomes was an increase in neonatal hyperbilirubinemia and the need for phototherapy, especially in the group delivered before 38 completed weeks of gestation.

A meta-analysis including these trials and two smaller unpublished ones involving a total of 1,190 women with suspected fetal macrosomia (a heterogeneous cohort of nulliparous, multiparous, diabetic, and nondiabetic women) has been published (111). Compared with expectant management, induction of labor for suspected fetal macrosomia reduced the risk of shoulder dystocia (RR, 0.60; 95% CI, 0.37–0.98) and any type of fracture (RR, 0.20; 95% CI, 0.05–0.79) with no change in the risk of cesarean delivery (RR 0.91, 95% CI 0.76–1.09) or instrumental delivery (RR, 0.86; 95% CI, 0.65–1.13). However, there were no differences between the groups for brachial plexus injury, although this outcome was infrequent (RR, 0.21; 95% CI, 0.01–4.28).

The College and the American Academy of Pediatrics recommend against delivery before 39 0/7 weeks of gestation unless it is medically indicated. Whether intervention is better than expectant management for suspected large-for-gestational-age infants, and the gestational age at which delivery should be performed are unclear (112). Although the meta-analysis of available trials is provocative and raises questions for further study, it is not clear that a reduction in shoulder dystocia would be seen with induction of labor after 39 0/7 weeks of gestation (111). At this time, and until additional studies are reported, the College continues to recommend against induction of labor for a suspected large-for-gestational-age infant at any gestational age.

▶ *How many cesarean deliveries for suspected fetal macrosomia would have to be performed to prevent one case of brachial plexus injury?*

The cost-effectiveness of cesarean delivery for fetal macrosomia usually is expressed as the number of cesarean deliveries required to prevent one brachial plexus injury or the cost, in dollars, of each brachial plexus injury avoided. A case–control study demonstrated that 51 cesarean deliveries would be needed to prevent one case of brachial plexus injury if the cutoff for cesarean delivery was 4,500 g among patients who do not have diabetes (37). For a cutoff of 5,000 g, this number decreased to 19 cesarean deliveries. Assuming rates for persistent brachial plexus impairment are between 5% and 22%, the authors of the study suggested that to prevent a single permanent brachial plexus injury, the number of cesarean deliveries increases to between 233 and 1,026 for a birth-weight cutoff of 4,500 g and to between 85 and 373 for a cutoff of 5,000 g (37). Another study using similar methods concluded that between 155 and 588 cesarean deliveries would be needed to prevent a single permanent injury using a cutoff of 4,500 g for infants of women who do not have diabetes (63). However, because the authors did not consider the imperfect predictive values of ultrasonography for macrosomia, they likely underestimated the number of cesarean deliveries that would be needed to implement such a policy.

In two reports analyzing a policy of prophylactic cesarean delivery for macrosomia that took into account the reported sensitivity and specificity of ultrasonography for the detection of macrosomia (4,500 g or greater), it was calculated that 3,695 cesarean deliveries would be required to prevent one permanent injury at an additional cost of $8.7 million for each permanent injury avoided (113, 114). For pregnancies complicated by diabetes, the estimated ratios of cesarean deliveries and cost per permanent injury avoided were more favorable, although these figures were still high at 443 cesarean deliveries performed at a cost of $930,000 for each permanent injury avoided. Because of the lack of well-designed and well-executed randomized clinical trials, a policy of prophylactic cesarean delivery for suspected fetal macrosomia of less than 5,000 g would be economically unsound for pregnancies in the absence of maternal diabetes.

Another cost-effectiveness study compared the strategies of expectant management, induction of labor, and cesarean delivery to prevent permanent brachial plexus injuries among nondiabetic women with an estimated fetal weight of 4,500 g (115). The cost per injury-free newborn was $4,014 for expectant management, $5,212 for cesarean delivery, and $5,165 for induction of labor, which suggests that the expectant management is the preferred approach (115).

▶ *How should a diagnosis of suspected fetal macrosomia affect the management of labor and vaginal delivery?*

A clinician's suspicion of a large fetus on prenatal examination and communication of fetal size concerns to the patient has been associated with increased labor

and delivery interventions. In a nationally representative survey of U.S. women who gave birth between July 2011 and June 2012 (N=1,960), women with "suspected large babies" had increased adjusted odds of medically induced labor (adjusted OR, 1.9; 95% CI, 1.4–2.6) and were more likely to ask for cesarean deliveries (adjusted OR, 4.6; 95% CI, 2.8–7.6) and have planned cesarean deliveries (adjusted OR, 1.8; 95% CI, 1.0–4.5). Yet only 20% gave birth to an infant weighing 4,000 g or more (116). Obstetrician–gynecologists may not be aware of the effect of communicating fetal size concerns to patients on their perceptions about the likely course of labor and delivery and the need for certain perinatal interventions.

Perhaps the most important consideration for labor and delivery with suspected fetal macrosomia is the decision of whether to conduct a midpelvic operative vaginal delivery. Figure 2 shows that the risk of shoulder dystocia increases with assisted vaginal delivery. Case–control and cohort studies consistently demonstrate an increased risk of shoulder dystocia when the macrosomic fetus is delivered using forceps or vacuum extraction, especially with a midpelvic delivery for a prolonged second stage (7, 117). Rates of shoulder dystocia with midforceps deliveries of infants larger than 4,500 g have been reported to be more than 50%. Barring unusual circumstances, cesarean delivery should be performed for midpelvic arrest of the fetus with suspected macrosomia.

Suspected fetal macrosomia is not a contraindication to a trial of labor after cesarean (TOLAC). Women undergoing TOLAC with a macrosomic fetus have a lower likelihood of vaginal birth after cesarean delivery (VBAC) than women attempting TOLAC who have a nonmacrosomic fetus (118, 119). Although success rates of TOLAC decrease the more the infant's birth weight exceeds 4,000 g (118, 119), this effect does not decrease absolute VBAC success rates to less than 50% in women who have had a previous vaginal delivery or previous VBAC (119). Studies have shown mixed results when examining the incidence of uterine rupture during a TOLAC with neonatal birth weights greater than 4,000 g. Three studies report finding no association (118, 120, 121), whereas a fourth suggests an increased risk of uterine rupture (RR, 2.3; $P<.001$) for women undergoing TOLAC who have not had a prior vaginal delivery (119). These studies used actual birth weight as opposed to estimated fetal weight, thus limiting the applicability of these data to making decisions regarding mode of delivery before labor (122). It is appropriate for patients and obstetrician–gynecologists and other obstetric care providers to consider past and predicted birth weights when making decisions regarding TOLAC, but suspected macrosomia alone should not preclude the possibility of a TOLAC.

Summary of Recommendations and Conclusions

The following conclusion is based on good and consistent scientific evidence (Level A):

- The diagnosis of fetal macrosomia is imprecise. For suspected fetal macrosomia, the accuracy of estimated fetal weight using ultrasound biometry is no better than that obtained with clinical palpation.

The following recommendations and conclusions are based on limited or inconsistent scientific evidence (Level B):

- Suspected fetal macrosomia is not an indication for induction of labor because induction does not improve maternal or fetal outcomes.
- With an estimated fetal weight of greater than 4,500 g, a prolonged second stage of labor or arrest of descent in the second stage is an indication for cesarean delivery.
- Barring unusual circumstances, cesarean delivery should be performed for midpelvic arrest of the fetus with suspected macrosomia.
- As with clinical estimates of fetal weight, the true value of ultrasonography in the management of expected fetal macrosomia may be its ability to rule out the diagnosis, which may help to avoid maternal morbidity.

The following recommendations and conclusions are based primarily on consensus and expert opinion (Level C):

- Although the diagnosis of fetal macrosomia is imprecise, prophylactic cesarean delivery may be considered for suspected fetal macrosomia with an estimated fetal weight of at least 5,000 g in women without diabetes and at least 4,500 g in women with diabetes.
- Pregnant women with suspected fetal macrosomia should be provided individualized counseling about the risks and benefits of vaginal and cesarean delivery based on the degree of macrosomia.
- It is appropriate for patients and obstetrician–gynecologists and other obstetric care providers to

consider past and predicted birth weights when making decisions regarding TOLAC, but suspected macrosomia alone should not preclude the possibility of a TOLAC.

References

1. Alexander GR, Himes JH, Kaufman RB, Mor J, Kogan M. A United States national reference for fetal growth. Obstet Gynecol 1996;87:163–8. (Level III) [PubMed] [*Obstetrics & Gynecology*] ⇦
2. Brenner WE, Edelman DA, Hendricks CH. A standard of fetal growth for the United States of America. Am J Obstet Gynecol 1976;126:555–64. (Level III) [PubMed] ⇦
3. Lubchenco LO, Hansman C, Dressler M, Boyd E. Intrauterine growth as estimated from liveborn birthweight data at 24 to 42 weeks of gestation. Pediatrics 1963;32:793–800. (Level III) [PubMed] [Full Text] ⇦
4. Duryea EL, Hawkins JS, McIntire DD, Casey BM, Leveno KJ. A revised birth weight reference for the United States. Obstet Gynecol 2014;124:16–22. (Level II-3) [PubMed] [*Obstetrics & Gynecology*]⇦
5. Modanlou HD, Dorchester WL, Thorosian A, Freeman RK. Macrosomia--maternal, fetal, and neonatal implications. Obstet Gynecol 1980;55:420–4. (Level II-2) [PubMed] [*Obstetrics & Gynecology*]⇦
6. Spellacy WN, Miller S, Winegar A, Peterson PQ. Macrosomia--maternal characteristics and infant complications. Obstet Gynecol 1985;66:158–61. (Level II-2) [PubMed] [*Obstetrics & Gynecology*] ⇦
7. Nesbitt TS, Gilbert WM, Herrchen B. Shoulder dystocia and associated risk factors with macrosomic infants born in California. Am J Obstet Gynecol 1998;179:476–80. (Level II-3) [PubMed] ⇦
8. Boulet SL, Alexander GR, Salihu HM, Pass M. Macrosomic births in the United States: determinants, outcomes, and proposed grades of risk. Am J Obstet Gynecol 2003;188:1372–8. (Level II-3) [PubMed] [Full Text] ⇦
9. Zhang X, Decker A, Platt RW, Kramer MS. How big is too big? The perinatal consequences of fetal macrosomia. Am J Obstet Gynecol 2008;198:517.e1–6. (Level II-3) [PubMed] [Full Text] ⇦
10. Buck Louis GM, Grewal J, Albert PS, Sciscione A, Wing DA, Grobman WA, et al. Racial/ethnic standards for fetal growth: the NICHD Fetal Growth Studies. Am J Obstet Gynecol 2015;213:449.e1–41. (Level II-3) [PubMed] [Full Text] ⇦
11. Pasupathy D, McCowan LM, Poston L, Kenny LC, Dekker GA, North RA. Perinatal outcomes in large infants using customised birthweight centiles and conventional measures of high birthweight. SCOPE consortium. Paediatr Perinat Epidemiol 2012;26:543–52. (Level II-3) [PubMed] ⇦
12. Larkin JC, Speer PD, Simhan HN. A customized standard of large size for gestational age to predict intrapartum morbidity. Am J Obstet Gynecol 2011;204:499.e1–10. (Level II-3) [PubMed] [Full Text] ⇦
13. Sjaarda LA, Albert PS, Mumford SL, Hinkle SN, Mendola P, Laughon SK. Customized large-for-gestational-age birthweight at term and the association with adverse perinatal outcomes. Am J Obstet Gynecol 2014;210:63.e1–11. (Level II-3) [PubMed] [Full Text] ⇦
14. Hamilton BE, Martin JA, Osterman MJ, Curtin SC, Matthews TJ. Births: final data for 2014. Natl Vital Stat Rep 2015;64:1–64. (Level II-3) [PubMed] [Full Text] ⇦
15. Gherman RB, Chauhan S, Ouzounian JG, Lerner H, Gonik B, Goodwin TM. Shoulder dystocia: the unpreventable obstetric emergency with empiric management guidelines. Am J Obstet Gynecol 2006;195:657–72. (Level III) [PubMed] [Full Text] ⇦
16. Menticoglou SM, Manning FA, Morrison I, Harman CR. Must macrosomic fetuses be delivered by a caesarean section? A review of outcome for 786 babies greater than or equal to 4,500 g. Aust N Z J Obstet Gynaecol 1992; 32:100–3. (Level III) [PubMed] ⇦
17. Lipscomb KR, Gregory K, Shaw K. The outcome of macrosomic infants weighing at least 4500 grams: Los Angeles County + University of Southern California experience. Obstet Gynecol 1995;85:558–64. (Level II-3) [PubMed] [*Obstetrics & Gynecology*] ⇦
18. Resnik R. Management of shoulder girdle dystocia. Clin Obstet Gynecol 1980;23:559–64. (Level III) [PubMed] ⇦
19. Gonik B, Hollyer VL, Allen R. Shoulder dystocia recognition: differences in neonatal risks for injury. Am J Perinatol 1991;8:31–4. (Level II-3) [PubMed] ⇦
20. Gross SJ, Shime J, Farine D. Shoulder dystocia: predictors and outcome. A five-year review. Am J Obstet Gynecol 1987;156:334–6. (Level II-3) [PubMed] ⇦
21. Bahar AM. Risk factors and fetal outcome in cases of shoulder dystocia compared with normal deliveries of a similar birthweight. Br J Obstet Gynaecol 1996;103: 868–72. (Level II-2) [PubMed] ⇦
22. American College of Obstetricians and Gynecologists. Neonatal brachial plexus palsy. Washington, DC: American College of Obstetricians and Gynecologists; 2014. (Level III) [PubMed] ⇦
23. Ehrenberg HM, Mercer BM, Catalano PM. The influence of obesity and diabetes on the prevalence of macrosomia. Am J Obstet Gynecol 2004;191:964–8. (Level II-3) [PubMed] [Full Text] ⇦
24. Getahun D, Ananth CV, Peltier MR, Salihu HM, Scorza WE. Changes in prepregnancy body mass index between the first and second pregnancies and risk of large-for-gestational-age birth. Am J Obstet Gynecol 2007;196:530.e1–8. (Level II-3) [PubMed] [Full Text] ⇦
25. Ferraro ZM, Barrowman N, Prud'homme D, Walker M, Wen SW, Rodger M, et al. Excessive gestational weight gain predicts large for gestational age neonates independent of maternal body mass index. J Matern Fetal Neonatal Med 2012;25:538–42. (Level II-3) [PubMed] [Full Text] ⇦

26. Alberico S, Montico M, Barresi V, Monasta L, Businelli C, Soini V, et al. The role of gestational diabetes, pre-pregnancy body mass index and gestational weight gain on the risk of newborn macrosomia: results from a prospective multicentre study. Multicentre Study Group on Mode of Delivery in Friuli Venezia Giulia. BMC Pregnancy Childbirth 2014;14:23. (Level II-2) [PubMed] [Full Text] ⇦
27. Institute of Medicine. Weight gain during pregnancy: reexamining the guidelines. Washington, DC: National Academies Press; 2009. (Level III) [PubMed] [Full Text] ⇦
28. Dietz PM, Callaghan WM, Sharma AJ. High pregnancy weight gain and risk of excessive fetal growth. Am J Obstet Gynecol 2009;201:51.e1,51.e6. (Level II-3) [PubMed] [Full Text] ⇦
29. Bowers K, Laughon SK, Kiely M, Brite J, Chen Z, Zhang C. Gestational diabetes, pre-pregnancy obesity and pregnancy weight gain in relation to excess fetal growth: variations by race/ethnicity. Diabetologia 2013; 56:1263–71. (Level II-3) [PubMed] [Full Text] ⇦
30. Okun N, Verma A, Mitchell BF, Flowerdew G. Relative importance of maternal constitutional factors and glucose intolerance of pregnancy in the development of newborn macrosomia. J Matern Fetal Med 1997; 6:285–90. (Level II-2) [PubMed] ⇦
31. Sermer M, Naylor CD, Gare DJ, Kenshole AB, Ritchie JW, Farine D, et al. Impact of increasing carbohydrate intolerance on maternal-fetal outcomes in 3637 women without gestational diabetes. The Toronto Tri-Hospital Gestational Diabetes Project. Am J Obstet Gynecol 1995;173:146–56. (Level II-2) [PubMed] [Full Text] ⇦
32. Metzger BE, Lowe LP, Dyer AR, Trimble ER, Chaovarindr U, Coustan DR, et al. Hyperglycemia and adverse pregnancy outcomes. HAPO Study Cooperative Research Group. N Engl J Med 2008;358:1991–2002. (Level II-2) [PubMed] [Full Text] ⇦
33. Naylor CD, Sermer M, Chen E, Sykora K. Cesarean delivery in relation to birth weight and gestational glucose tolerance: pathophysiology or practice style? Toronto Trihospital Gestational Diabetes Investigators. JAMA 1996;275:1165–70. (Level II-2) [PubMed] ⇦
34. Adams KM, Li H, Nelson RL, Ogburn PL Jr, Danilenko-Dixon DR. Sequelae of unrecognized gestational diabetes. Am J Obstet Gynecol 1998;178:1321–32. (Level II-2) [PubMed] ⇦
35. Nasrat H, Abalkhail B, Fageeh W, Shabat A, el Zahrany F. Anthropometric measurement of newborns of gestational diabetic mothers: does it indicate disproportionate fetal growth? J Matern Fetal Med 1997;6:291–5. (Level II-2) [PubMed] ⇦
36. McFarland MB, Trylovich CG, Langer O. Anthropometric differences in macrosomic infants of diabetic and nondiabetic mothers. J Matern Fetal Med 1998;7: 292–5. (Level II-2) [PubMed] ⇦
37. Ecker JL, Greenberg JA, Norwitz ER, Nadel AS, Repke JT. Birth weight as a predictor of brachial plexus injury. Obstet Gynecol 1997;89:643–7. (Level II-2) [PubMed] [*Obstetrics & Gynecology*] ⇦
38. Casey BM, Lucas MJ, Mcintire DD, Leveno KJ. Pregnancy outcomes in women with gestational diabetes compared with the general obstetric population. Obstet Gynecol 1997;90:869–73. (Level II-2) [PubMed] [*Obstetrics & Gynecology*] ⇦
39. Bianco AT, Smilen SW, Davis Y, Lopez S, Lapinski R, Lockwood CJ. Pregnancy outcome and weight gain recommendations for the morbidly obese woman. Obstet Gynecol 1998;91:97–102. (Level II-2) [PubMed] [*Obstetrics & Gynecology*] ⇦
40. Siega-Riz AM, Viswanathan M, Moos MK, Deierlein A, Mumford S, Knaack J, et al. A systematic review of outcomes of maternal weight gain according to the Institute of Medicine recommendations: birthweight, fetal growth, and postpartum weight retention. Am J Obstet Gynecol 2009;201:339.e1–14. (Level III) [PubMed] [Full Text] ⇦
41. Boulet SL, Salihu HM, Alexander GR. Mode of delivery and birth outcomes of macrosomic infants. J Obstet Gynaecol 2004;24:622–9. (Level III) [PubMed] [Full Text] ⇦
42. Klebanoff MA, Mills JL, Berendes HW. Mother's birth weight as a predictor of macrosomia. Am J Obstet Gynecol 1985;153:253–7. (Level II-2) [PubMed] ⇦
43. Lunde A, Melve KK, Gjessing HK, Skjaerven R, Irgens LM. Genetic and environmental influences on birth weight, birth length, head circumference, and gestational age by use of population-based parent-offspring data. Am J Epidemiol 2007;165:734–41. (Level II-3) [PubMed] [Full Text] ⇦
44. Deter RL, Hadlock FP. Use of ultrasound in the detection of macrosomia: a review. J Clin Ultrasound 1985;13:519–24. (Level III) [PubMed] ⇦
45. Sandmire HF. Whither ultrasonic prediction of fetal macrosomia? Obstet Gynecol 1993;82:860–2. (Level III) [PubMed] [*Obstetrics & Gynecology*] ⇦
46. Zhang J, Kim S, Grewal J, Albert PS. Predicting large fetuses at birth: do multiple ultrasound examinations and longitudinal statistical modelling improve prediction? Paediatr Perinat Epidemiol 2012;26:199–207. (Level II-2) [PubMed] [Full Text] ⇦
47. Costantine MM, Mele L, Landon MB, Spong CY, Ramin SM, Casey B, et al. Customized versus population approach for evaluation of fetal overgrowth. Eunice Kennedy Shriver National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network, Bethesda, Maryland. Am J Perinatol 2013;30:565–72. (Level II-3) [PubMed] [Full Text] ⇦
48. Chauhan SP, Hendrix NW, Magann EF, Morrison JC, Kenney SP, Devoe LD. Limitations of clinical and sonographic estimates of birth weight: experience with 1034 parturients. Obstet Gynecol 1998;91:72–7. (Level II-2) [PubMed] [*Obstetrics & Gynecology*] ⇦
49. Kayem G, Grange G, Breart G, Goffinet F. Comparison of fundal height measurement and sonographically measured fetal abdominal circumference in the prediction of high and low birth weight at term. Ultrasound Obstet Gynecol 2009;34:566–71. (Level II-3) [PubMed] [Full Text] ⇦

50. Chauhan SP, Sullivan CA, Lutton TC, Magann EF, Morrison JC. Parous patients' estimate of birth weight in postterm pregnancy. J Perinatol 1995;15:192–4. (Level II-2) [PubMed] ⇦

51. Harlev A, Walfisch A, Bar-David J, Hershkovitz R, Friger M, Hallak M. Maternal estimation of fetal weight as a complementary method of fetal weight assessment: a prospective clinical trial. J Reprod Med 2006;51:515–20. (Level II-3) [PubMed] ⇦

52. Sadeh-Mestechkin D, Walfisch A, Shachar R, Shoham-Vardi I, Vardi H, Hallak M. Suspected macrosomia? Better not tell. Arch Gynecol Obstet 2008;278:225–30. (Level II-3) [PubMed] ⇦

53. Blackwell SC, Refuerzo J, Chadha R, Carreno CA. Overestimation of fetal weight by ultrasound: does it influence the likelihood of cesarean delivery for labor arrest? Am J Obstet Gynecol 2009;200:340.e1–3. (Level II-3) [PubMed] [Full Text] ⇦

54. Melamed N, Yogev Y, Meizner I, Mashiach R, Pardo J, Ben-Haroush A. Prediction of fetal macrosomia: effect of sonographic fetal weight-estimation model and threshold used. Ultrasound Obstet Gynecol 2011;38: 74–81. (Level III) [PubMed] [Full Text] ⇦

55. Barber EL, Lundsberg LS, Belanger K, Pettker CM, Funai EF, Illuzzi JL. Indications contributing to the increasing cesarean delivery rate. Obstet Gynecol 2011; 118:29–38. (Level II-3) [PubMed] [*Obstetrics & Gynecology*] ⇦

56. Stones RW, Paterson CM, Saunders NJ. Risk factors for major obstetric haemorrhage. Eur J Obstet Gynecol Reprod Biol 1993;48:15–8. (Level II-2) [PubMed] ⇦

57. Gupta N, Kiran TU, Mulik V, Bethel J, Bhal K. The incidence, risk factors and obstetric outcome in primigravid women sustaining anal sphincter tears. Acta Obstet Gynecol Scand 2003;82:736–43. (Level II-3) [PubMed] [Full Text] ⇦

58. Jastrow N, Roberge S, Gauthier RJ, Laroche L, Duperron L, Brassard N, et al. Effect of birth weight on adverse obstetric outcomes in vaginal birth after cesarean delivery. Obstet Gynecol 2010;115:338–43. (Level II-3) [PubMed] [*Obstetrics & Gynecology*] ⇦

59. Gauthaman N, Walters S, Tribe IA, Goldsmith L, Doumouchtsis SK. Shoulder dystocia and associated manoeuvres as risk factors for perineal trauma. Int Urogynecol J 2016;27:571–7. (Level II-3) [PubMed] [Full Text] ⇦

60. Ahn ES, Jung MS, Lee YK, Ko SY, Shin SM, Hahn MH. Neonatal clavicular fracture: recent 10 year study. Pediatr Int 2015;57:60–3. (Level II-3) [PubMed] ⇦

61. Perlow JH, Wigton T, Hart J, Strassner HT, Nageotte MP, Wolk BM. Birth trauma. A five-year review of incidence and associated perinatal factors. J Reprod Med 1996;41:754–60. (Level II-2) [PubMed] ⇦

62. McFarland LV, Raskin M, Daling JR, Benedetti TJ. Erb/Duchenne's palsy: a consequence of fetal macrosomia and method of delivery. Obstet Gynecol 1986;68: 784–8. (Level II-2) [PubMed] [*Obstetrics & Gynecology*] ⇦

63. Bryant DR, Leonardi MR, Landwehr JB, Bottoms SF. Limited usefulness of fetal weight in predicting neonatal brachial plexus injury. Am J Obstet Gynecol 1998;179:686–9. (Level II-3) [PubMed] ⇦

64. Esakoff TF, Cheng YW, Sparks TN, Caughey AB. The association between birthweight 4000 g or greater and perinatal outcomes in patients with and without gestational diabetes mellitus. Am J Obstet Gynecol 2009;200:672.e1–4. (Level II-2) [PubMed] [Full Text] ⇦

65. Gordon M, Rich H, Deutschberger J, Green M. The immediate and long-term outcome of obstetric birth trauma. I. Brachial plexus paralysis. Am J Obstet Gynecol 1973; 117:51–6. (Level II-2) [PubMed] ⇦

66. Morrison JC, Sanders JR, Magann EF, Wiser WL. The diagnosis and management of dystocia of the shoulder. Surg Gynecol Obstet 1992;175:515–22. (Level II-3) [PubMed] ⇦

67. Hardy AE. Birth injuries of the brachial plexus: incidence and prognosis. J Bone Joint Surg Br 1981; 63-B:98–101. (Level III) [PubMed] ⇦

68. Gherman RB, Ouzounian JG, Satin AJ, Goodwin TM, Phelan JP. A comparison of shoulder dystocia-associated transient and permanent brachial plexus palsies. Obstet Gynecol 2003;102:544–8. (Level II-3) [PubMed] [*Obstetrics & Gynecology*] ⇦

69. Kolderup LB, Laros RK Jr, Musci TJ. Incidence of persistent birth injury in macrosomic infants: association with mode of delivery. Am J Obstet Gynecol 1997;177:37–41. (Level II-2) [PubMed] [Full Text] ⇦

70. Gillean JR, Coonrod DV, Russ R, Bay RC. Big infants in the neonatal intensive care unit. Am J Obstet Gynecol 2005;192:1948–53; discussion 1953–5. (Level II-3) [PubMed] [Full Text] ⇦

71. Cnattingius S, Villamor E, Lagerros YT, Wikstrom AK, Granath F. High birth weight and obesity--a vicious circle across generations. Int J Obes (Lond) 2012;36:1320–4. (Level II-3) [PubMed] ⇦

72. Sparano S, Ahrens W, De Henauw S, Marild S, Molnar D, Moreno LA, et al. Being macrosomic at birth is an independent predictor of overweight in children: results from the IDEFICS study. Matern Child Health J 2013; 17:1373–81. (Level II-3) [PubMed] ⇦

73. Chauhan SP, Cowan BD, Magann EF, Bradford TH, Roberts WE, Morrison JC. Intrapartum detection of a macrosomic fetus: clinical versus 8 sonographic models. Aust N Z J Obstet Gynaecol 1995;35:266–70. (Level II-2) [PubMed] ⇦

74. Chauhan SP, West DJ, Scardo JA, Boyd JM, Joiner J, Hendrix NW. Antepartum detection of macrosomic fetus: clinical versus sonographic, including soft-tissue measurements. Obstet Gynecol 2000;95:639–42. (Level II-3) [PubMed] [*Obstetrics & Gynecology*]⇦

75. Sherman DJ, Arieli S, Tovbin J, Siegel G, Caspi E, Bukovsky I. A comparison of clinical and ultrasonic estimation of fetal weight. Obstet Gynecol 1998;91:212–7. (Level II-3) [PubMed] [*Obstetrics & Gynecology*] ⇦

76. Weiner Z, Ben-Shlomo I, Beck-Fruchter R, Goldberg Y, Shalev E. Clinical and ultrasonographic weight estimation

in large for gestational age fetus. Eur J Obstet Gynecol Reprod Biol 2002;105:20–4. (Level II-3) [PubMed] [Full Text] ⇦

77. Sparks TN, Cheng YW, McLaughlin B, Esakoff TF, Caughey AB. Fundal height: a useful screening tool for fetal growth? J Matern Fetal Neonatal Med 2011;24: 708–12. (Level II-3) [PubMed] [Full Text] ⇦

78. Goetzinger KR, Odibo AO, Shanks AL, Roehl KA, Cahill AG. Clinical accuracy of estimated fetal weight in term pregnancies in a teaching hospital. J Matern Fetal Neonatal Med 2014;27:89–93. (Level II-3) [PubMed] [Full Text] ⇦

79. Drassinower D, Timofeev J, Huang CC, Benson JE, Driggers RW, Landy HJ. Accuracy of clinically estimated fetal weight in pregnancies complicated by diabetes mellitus and obesity. Am J Perinatol 2014;31:31–7. (Level II-3) [PubMed] ⇦

80. Goetzinger KR, Tuuli MG, Odibo AO, Roehl KA, Macones GA, Cahill AG. Screening for fetal growth disorders by clinical exam in the era of obesity. J Perinatol 2013;33:352–7. (Level II-3) [PubMed] [Full Text] ⇦

81. Gonen R, Spiegel D, Abend M. Is macrosomia predictable, and are shoulder dystocia and birth trauma preventable? Obstet Gynecol 1996;88:526–9. (Level II-3) [PubMed] [*Obstetrics & Gynecology*] ⇦

82. Johnstone FD, Prescott RJ, Steel JM, Mao JH, Chambers S, Muir N. Clinical and ultrasound prediction of macrosomia in diabetic pregnancy. Br J Obstet Gynaecol 1996;103:747–54. (Level II-3) [PubMed] ⇦

83. Hadlock FP, Harrist RB, Carpenter RJ, Deter RL, Park SK. Sonographic estimation of fetal weight. The value of femur length in addition to head and abdomen measurements. Radiology 1984;150:535–40. (Level II-3) [PubMed] ⇦

84. Shepard MJ, Richards VA, Berkowitz RL, Warsof SL, Hobbins JC. An evaluation of two equations for predicting fetal weight by ultrasound. Am J Obstet Gynecol 1982;142:47–54. (Level II-3) [PubMed] ⇦

85. Alsulyman OM, Ouzounian JG, Kjos SL. The accuracy of intrapartum ultrasonographic fetal weight estimation in diabetic pregnancies. Am J Obstet Gynecol 1997;177: 503–6. (Level II-2) [PubMed] [Full Text] ⇦

86. Smith GC, Smith MF, McNay MB, Fleming JE. The relation between fetal abdominal circumference and birthweight: findings in 3512 pregnancies. Br J Obstet Gynaecol 1997;104:186–90. (Level II-3) [PubMed] ⇦

87. O'Reilly-Green CP, Divon MY. Receiver operating characteristic curves of sonographic estimated fetal weight for prediction of macrosomia in prolonged pregnancies. Ultrasound Obstet Gynecol 1997;9:403–8. (Level II-3) [PubMed] [Full Text] ⇦

88. Coomarasamy A, Connock M, Thornton J, Khan KS. Accuracy of ultrasound biometry in the prediction of macrosomia: a systematic quantitative review. BJOG 2005; 112:1461–6. (Meta-analysis) [PubMed] [Full Text] ⇦

89. Benacerraf BR, Gelman R, Frigoletto FD Jr. Sonographically estimated fetal weights: accuracy and limitation. Am J Obstet Gynecol 1988;159:1118–21. (Level II-2) [PubMed] ⇦

90. McLaren RA, Puckett JL, Chauhan SP. Estimators of birth weight in pregnant women requiring insulin: a comparison of seven sonographic models. Obstet Gynecol 1995;85:565–9. (Level II-2) [PubMed] [*Obstetrics & Gynecology*] ⇦

91. Hoopmann M, Abele H, Wagner N, Wallwiener D, Kagan KO. Performance of 36 different weight estimation formulae in fetuses with macrosomia. Fetal Diagn Ther 2010;27:204–13. (Level III) [PubMed] [Full Text] ⇦

92. Melamed N, Yogev Y, Meizner I, Mashiach R, Ben-Haroush A. Sonographic prediction of fetal macrosomia: the consequences of false diagnosis. J Ultrasound Med 2010;29:225–30. (Level II-3) [PubMed] [Full Text] ⇦

93. Skrastad RB, Eik-Nes SH, Sviggum O, Johansen OJ, Salvesen KA, Romundstad PR, et al. A randomized controlled trial of third-trimester routine ultrasound in a non-selected population. Acta Obstet Gynecol Scand 2013;92:1353–60. (Level III) [PubMed] [Full Text] ⇦

94. Dodd JM, Turnbull D, McPhee AJ, Deussen AR, Grivell RM, Yelland LN, et al. Antenatal lifestyle advice for women who are overweight or obese: LIMIT randomised trial. LIMIT Randomised Trial Group. BMJ 2014;348:g1285. (Level I) [PubMed] [Full Text] ⇦

95. de Oliveria Melo AS, Silva JL, Tavares JS, Barros VO, Leite DF, Amorim MM. Effect of a physical exercise program during pregnancy on uteroplacental and fetal blood flow and fetal growth: a randomized controlled trial. Obstet Gynecol 2012;120:302–10. (Level I) [PubMed] [*Obstetrics & Gynecology*]⇦

96. Barakat R, Pelaez M, Cordero Y, Perales M, Lopez C, Coteron J, et al. Exercise during pregnancy protects against hypertension and macrosomia: randomized clinical trial. Am J Obstet Gynecol 2016;214:649.e1–8. (Level I) [PubMed] [Full Text] ⇦

97. Buchanan TA, Kjos SL, Montoro MN, Wu PY, Madrilejo NG, Gonzalez M, et al. Use of fetal ultrasound to select metabolic therapy for pregnancies complicated by mild gestational diabetes. Diabetes Care 1994;17:275–83. (Level II-1) [PubMed] ⇦

98. Crowther CA, Hiller JE, Moss JR, McPhee AJ, Jeffries WS, Robinson JS. Effect of treatment of gestational diabetes mellitus on pregnancy outcomes. Australian Carbohydrate Intolerance Study in Pregnant Women (ACHOIS) Trial Group. N Engl J Med 2005;352: 2477–86. (Level I) [PubMed] [Full Text] ⇦

99. Landon MB, Spong CY, Thom E, Carpenter MW, Ramin SM, Casey B, et al. A multicenter, randomized trial of treatment for mild gestational diabetes. Eunice Kennedy Shriver National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network. N Engl J Med 2009;361:1339–48. (Level I) [PubMed] [Full Text] ⇦

100. Gregory KD, Henry OA, Ramicone E, Chan LS, Platt LD. Maternal and infant complications in high and normal weight infants by method of delivery.

Obstet Gynecol 1998;92:507–13. (Level II-2) [PubMed] [*Obstetrics & Gynecology*] ⇦

101. Conway DL, Langer O. Elective delivery of infants with macrosomia in diabetic women: reduced shoulder dystocia versus increased cesarean deliveries. Am J Obstet Gynecol 1998;178:922–5. (Level II-2) [PubMed] ⇦

102. Berard J, Dufour P, Vinatier D, Subtil D, Vanderstichele S, Monnier JC, et al. Fetal macrosomia: risk factors and outcome. A study of the outcome concerning 100 cases >4500 g. Eur J Obstet Gynecol Reprod Biol 1998;77: 51–9. (Level II-3) [PubMed] [Full Text] ⇦

103. Blickstein I, Ben-Arie A, Hagay ZJ. Antepartum risks of shoulder dystocia and brachial plexus injury for infants weighing 4,200 g or more. Gynecol Obstet Invest 1998;45:77–80. (Level II-2) [PubMed] ⇦

104. Combs CA, Singh NB, Khoury JC. Elective induction versus spontaneous labor after sonographic diagnosis of fetal macrosomia. Obstet Gynecol 1993;81:492–6. (Level II-2) [PubMed] [*Obstetrics & Gynecology*] ⇦

105. Friesen CD, Miller AM, Rayburn WF. Influence of spontaneous or induced labor on delivering the macrosomic fetus. Am J Perinatol 1995;12:63–6. (Level II-2) [PubMed] ⇦

106. Leaphart WL, Meyer MC, Capeless EL. Labor induction with a prenatal diagnosis of fetal macrosomia. J Matern Fetal Med 1997;6:99–102. (Level II-2) [PubMed] ⇦

107. Cheng YW, Sparks TN, Laros RK Jr, Nicholson JM, Caughey AB. Impending macrosomia: will induction of labour modify the risk of caesarean delivery? BJOG 2012;119:402–9. (Level II-3) [PubMed] [Full Text] ⇦

108. Vendittelli F, Riviere O, Neveu B, Lemery D. Does induction of labor for constitutionally large-for-gestational-age fetuses identified in utero reduce maternal morbidity? Audipog Sentinel Network. BMC Pregnancy Childbirth 2014;14:156. (Level II-3) [PubMed] [Full Text] ⇦

109. Gonen O, Rosen DJ, Dolfin Z, Tepper R, Markov S, Fejgin MD. Induction of labor versus expectant management in macrosomia: a randomized study. Obstet Gynecol 1997;89:913–7. (Level I) [PubMed] [*Obstetrics & Gynecology*] ⇦

110. Boulvain M, Senat MV, Perrotin F, Winer N, Beucher G, Subtil D, et al. Induction of labour versus expectant management for large-for-date fetuses: a randomised controlled trial. Groupe de Recherche en Obstetrique et Gynecologie (GROG). Lancet 2015;385:2600–5. (Level I) [PubMed] [Full Text] ⇦

111. Boulvain M, Irion O, Dowswell T, Thornton JG. Induction of labour at or near term for suspected fetal macrosomia. Cochrane Database of Systematic Reviews 2016, Issue 5. Art. No.: CD000938. DOI: 10.1002/14651858. CD000938.pub2. (Level III) [PubMed] [Full Text] ⇦

112. Caughey AB. Should pregnancies be induced for impending macrosomia? Lancet 2015;385:2557–9. (Level III) [PubMed] [Full Text] ⇦

113. Rouse DJ, Owen J, Goldenberg RL, Cliver SP. The effectiveness and costs of elective cesarean delivery for fetal macrosomia diagnosed by ultrasound. JAMA 1996;276:1480–6. (Level III) [PubMed] ⇦

114. Rouse DJ, Owen J. Prophylactic cesarean delivery for fetal macrosomia diagnosed by means of ultrasonography--A Faustian bargain? Am J Obstet Gynecol 1999;181:332–8. (Level III) [PubMed] [Full Text] ⇦

115. Herbst MA. Treatment of suspected fetal macrosomia: a cost-effectiveness analysis. Am J Obstet Gynecol 2005; 193:1035–9. (Cost-benefit) [PubMed] [Full Text] ⇦

116. Cheng ER, Declercq ER, Belanoff C, Stotland NE, Iverson RE. Labor and delivery experiences of mothers with suspected large babies. Matern Child Health J 2015;19:2578–86. (Level II-3) [PubMed] [Full Text] ⇦

117. Benedetti TJ, Gabbe SG. Shoulder dystocia. A complication of fetal macrosomia and prolonged second stage of labor with midpelvic delivery. Obstet Gynecol 1978;52:526–9. (Level III) [PubMed] [*Obstetrics & Gynecology*] ⇦

118. Flamm BL, Goings JR. Vaginal birth after cesarean section: is suspected fetal macrosomia a contraindication? Obstet Gynecol 1989;74:694–7. (Level II-2) [PubMed] [*Obstetrics & Gynecology*] ⇦

119. Elkousy MA, Sammel M, Stevens E, Peipert JF, Macones G. The effect of birth weight on vaginal birth after cesarean delivery success rates. Am J Obstet Gynecol 2003; 188:824–30. (Level II-3) [PubMed] [Full Text] ⇦

120. Leung AS, Farmer RM, Leung EK, Medearis AL, Paul RH. Risk factors associated with uterine rupture during trial of labor after cesarean delivery: a case-control study. Am J Obstet Gynecol 1993;168:1358–63. (Level II-2) [PubMed] ⇦

121. Zelop CM, Shipp TD, Repke JT, Cohen A, Lieberman E. Outcomes of trial of labor following previous cesarean delivery among women with fetuses weighing >4000 g. Am J Obstet Gynecol 2001;185:903–5. (Level II-3) [PubMed] [Full Text] ⇦

122. Chauhan SP, Grobman WA, Gherman RA, Chauhan VB, Chang G, Magann EF, et al. Suspicion and treatment of the macrosomic fetus: a review. Am J Obstet Gynecol 2005;193:332–46. (Level III) [PubMed] [Full Text] ⇦

The MEDLINE database, the Cochrane Library, and the American College of Obstetricians and Gynecologists' own internal resources and documents were used to conduct a literature search to locate relevant articles published between January 1985–January 2015. The search was restricted to articles published in the English language. Priority was given to articles reporting results of original research, although review articles and commentaries also were consulted. Abstracts of research presented at symposia and scientific conferences were not considered adequate for inclusion in this document. Guidelines published by organizations or institutions such as the National Institutes of Health and the American College of Obstetricians and Gynecologists were reviewed, and additional studies were located by reviewing bibliographies of identified articles. When reliable research was not available, expert opinions from obstetrician–gynecologists were used.

Studies were reviewed and evaluated for quality according to the method outlined by the U.S. Preventive Services Task Force:

- I Evidence obtained from at least one properly designed randomized controlled trial.
- II-1 Evidence obtained from well-designed controlled trials without randomization.
- II-2 Evidence obtained from well-designed cohort or case–control analytic studies, preferably from more than one center or research group.
- II-3 Evidence obtained from multiple time series with or without the intervention. Dramatic results in uncontrolled experiments also could be regarded as this type of evidence.
- III Opinions of respected authorities, based on clinical experience, descriptive studies, or reports of expert committees.

Based on the highest level of evidence found in the data, recommendations are provided and graded according to the following categories:

Level A—Recommendations are based on good and consistent scientific evidence.

Level B—Recommendations are based on limited or inconsistent scientific evidence.

Level C—Recommendations are based primarily on consensus and expert opinion.

Copyright November 2016 by the American College of Obstetricians and Gynecologists. All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, posted on the Internet, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher.

Requests for authorization to make photocopies should be directed to Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400.

ISSN 1099-3630

The American College of Obstetricians and Gynecologists
409 12th Street, SW, PO Box 96920, Washington, DC 20090-6920

Fetal macrosomia. Practice Bulletin No. 173. American College of Obstetricians and Gynecologists. Obstet Gynecol 2016;128:e195–209.