BY SUNEET P. CHAUHAN, MD, and CHRISTINE E. HENRICHS, MD

OBG MANAGEMENT

Obesity in pregnancy: Risks and interventions by gestational stage

Gestational diabetes, preeclampsia, prolonged hospitalization—these are just a few of the complications that may affect obese gravidas. Here, the authors present a rundown of what to look for when treating this unique population.

Specific interventions can help reduce the complications associated with obesity in pregnancy, provided physicians remain vigilant in applying the appropriate preventive measures.

Since one third of American women of childbearing age are overweight, obesity clearly has a major impact on the health of pregnant patients. And, as in the general population, the prevalence of this condition is escalating among gravidas. A 2001 study cited a 20% increase in mean maternal weights between 1980 and 1999.[1]

In the United States, the prevalence of obesity leaped from 12% to 17.9% between 1991 and 1998.[2] Even more alarmingly, each year in this country, 280,000 adult deaths are attributable to obesity.

As health-care providers, it is imperative that we understand the impact this epidemic has on pregnancy and delivery so that we can work to minimize related complications.

▪ *Dr. Chauhan is director, maternal-fetal medicine, Spartanburg Regional Medical Center, Spartanburg, SC. Dr. Henrichs is Faculty Development Fellow, University of Pittsburgh Medical Center St. Margaret, Pittsburgh, Pa.*

What is obesity?

There is no single definition of obesity. In obstetric literature, it has been defined as a maternal weight of more than 90 kg (200 lb), more than 114 kg (250 lb), more than 135 kg (300 lb), and anywhere from 50% to 120% above ideal body weight.

In recent years, clinicians have usually determined obesity according to the body mass index (BMI), a simple mathematical formula (weight in kilograms divided by height in square meters) that correlates height and weight with body fat. This method offers several advantages over a basic weight

KEY POINTS

- All obese patients have an increased risk of gestational diabetes and preeclampsia.
- Deep venous thrombosis and its complications—which include maternal mortality—are seen more frequently in the obese patient.
- Obesity is associated with an increased likelihood of induction of labor and cesarean delivery.
- Obesity is a specific risk factor for several operative complications, including hemorrhage during surgery, postoperative wound infections, aspiration, and pulmonary embolism.

TABLE 1

Obstetric concerns among obese patients

Preconception	Pregestational diabetes mellitus Chronic hypertension
Antepartum period	Gestational diabetes Preeclampsia Deep venous thrombosis Stillbirth
Intrapartum period	Induction Cesarean delivery Poor VBAC success Macrosomia
Postpartum period	Prolonged hospitalization Cesarean complications Wound infection

VBAC = vaginal birth after cesarean

measurement. For one, weight alone does not correlate well with body fat content; BMI, on the other hand, has a 0.7 to 0.8 correlation. In addition, this definition of obesity correlates with morbidity and mortality.[3]

Using BMI, the Institute of Medicine developed 4 body-type categories[4]:

- under 19.8: lean
- 19.8 to 26.0: normal
- 26.1 to 29: overweight
- over 29: obese

In obstetric patients, BMI is calculated using prepregnancy weight. While the varying definitions of obesity make it difficult to compare and interpret research findings, it is important to note that adverse obstetric outcomes are associated with each classification. The Institute of Medicine also made recommendations on how much weight women in each category should gain during pregnancy[5]:

- lean women: 28 lb to 40 lb
- normal-weight women: 25 lb to 35 lb
- overweight women: 15 lb to 25 lb
- obese women: 15 lb or more

While no upper weight-gain limit was set for obese patients, 3 studies recommend 37 lb; researchers found that obese women who gain more than this have increased risk of cesarean delivery and large-for-gestational-age infants.[6-8]

Preconception: Control hypertension and diabetes

The negative impact that excess weight has on pregnancy begins even before conception (TABLE 1). For example, obese women are more likely to have chronic hypertension and diabetes. In 1 study, researchers reported the incidence of chronic hypertension among obese patients (defined as those weighing 300 lb or more) to be 33%, compared with 5% among controls, while diabetes occurred in 15% of obese patients and 3% of controls.[9]

Through preconception counseling and management, practitioners can improve pregnancy outcomes among patients with these medical complications. Strict glucose control of pregestational diabetes, for example, decreases the risk of congenital malformations. The 4-fold increase in malformations related to poor glucose control during embryogenesis is diminished if preconceptional glycosylated hemoglobin levels are in the normal range.[10]

CONTINUED

Note that hypertension may be falsely diagnosed in an obese woman if an inappropriately small cuff is used. When taking the blood pressure (BP) of these patients, therefore, clinicians should make sure the length of the cuff is 1.5 times the upper arm circumference or that the inflatable bladder of the cuff encircles at least 80% of the arm.[11] For women with an arm circumference of more than 41 cm, use a thigh cuff to ensure an accurate measurement.

In general, any hypertensive woman of childbearing age should take only agents with documented fetal safety. Drugs such as angiotensin-converting enzyme inhibitors should not be used due to their association with oligohydramnios, fetal hypocalvaria, and neonatal renal failure.

Antepartum

Gestational diabetes and preeclampsia. During pregnancy, all obese patients—even those without a history of hypertension or diabetes—have an increased risk of gestational diabetes and preeclampsia. Baeten et al[12] recently reported the odds ratios for gestational diabetes, preeclampsia, and eclampsia in the obese nulliparous patient as 5.2, 3.3, and 3.0, respectively.

What are the reasons for this? For one, obesity and pregnancy are both associated with increased insulin resistance. The combination of these 2 conditions can overwhelm the pancreas and unmask any small abnormality in its ability to secrete insulin.

The pathophysiology of preeclampsia is less clearly understood and, therefore, so is its link with obesity. However, Stone et al[13] theorized that the relationship between obesity and hyperlipidemia is what leads to preeclampsia. Hyperlipidemia damages endothelial cells through lipid peroxidases. This damage leads to increased vasoconstriction and platelet aggregation.

For the obese patient, clinicians should place increased emphasis on preeclampsia and gestational diabetes screening and prevention. The obese gravida should undergo early glucose screening along with regular BP measurements. Several studies have investigated possible interventions for women at high risk for pregnancy-induced hypertension. In 1 systematic review of 41 randomized controlled trials, aspirin was associated with a 15% reduction in the relative risk of preeclampsia (95% confidence interval, 0.78 to 0.92), with no increase in adverse outcomes.[14] Another systematic review found that calcium supplementation (at least 1 g per day) can reduce the risk of preeclampsia by 30%.[15] Still, no trials have examined aspirin or calcium supplementation among obese patients; the clinician must therefore weigh the benefits of these prophylactic measures.

The obese gravida should undergo early glucose screening along with regular blood pressure measurements.

Deep venous thrombosis. Along with preeclampsia and gestational diabetes, deep venous thrombosis and its complications—which include maternal mortality—are seen more frequently in the obese patient. One 10-year review in Minnesota looked at weight distributions for mothers who died. Researchers found that 12% of this population, compared with 2% of the control group, had prepregnancy weights greater than 200 lb.[16] The leading cause of death among the obese group was pulmonary embolus.

Fetal death. A large, population-based cohort study reported a relationship between maternal obesity and fetal death.[17] Among nulliparous women in this study, the risk of late fetal death (stillbirth occurring at 28 weeks' gestation or later) increased as the BMI rose. The obese woman was 4 times as likely to have a late fetal death as the lean woman. In parous women, the risk was only increased in the obese BMI category—rather than in all classifications of BMI. After excluding women with

TABLE 2

Obesity and cesarean delivery rates

AUTHORS	NUMBER OF SUBJECTS	OBESITY DEFINED AS	RATE OF CESAREAN DELIVERY	COMMENTS
Baeten et al, 2001[12]	9,817	BMI ≥30	Increased	—
Kaiser and Kirby, 2001[21]	452	BMI ≥29	Increased*	Population was low risk without prior cesarean.
Kumari, 2001[37]	188	BMI >40	Increased*	Elective* and emergency cesareans examined.
Steinfeld et al, 2000[38]	168	BMI ≥29	Increased*	Excluded elective cesareans and those performed due to fetal malpresentation and previa.
Jensen et al, 1999[39]	163	BMI ≥30	Increased	Excluded patients with prior cesarean.
Ranta et al, 1995[40]	53	BMI ≥30	Increased	—
Issacs et al, 1994[9]	117	>300 lb	Increased*	Primary and repeat cesareans examined.
Hood and Dewan, 1993[25]	117	>300 lb	Increased*	Elective and emergency* cesareans examined.
Ekblad and Grenman, 1992[20]	77	≥20%†	Increased	Emergency cesareans examined.
Perlow et al, 1992[35]	111	>300 lb	Increased*	Primary* cesareans and those performed due to fetal distress examined.
Pongthai, 1990[41]	741	≥80 kg	Increased*	Primary and repeat* cesareans examined.
Johnson et al, 1987[30]	588	>113.6 kg	Increased*	Primary cesareans examined only.
Garbaciak et al, 1985[36]	1,889	>120%†	Increased*	Primary cesareans examined only.
Gross et al, 1980[19]	279	≥90 kg	Increased	Repeat cesareans omitted.
Edwards et al, 1978[27]	208	>50%‡	Increased	—

BMI = body mass index

*Significant increase
†Over ideal body weight for height
‡Above standard weight for height on the Metropolitan Life Insurance tables

hypertensive diseases and diabetes, the association persisted. Huang et al[18] supported these findings by identifying maternal prepregnancy weight greater than 68 kg as a risk factor for unexplained fetal deaths, even after controlling for maternal diabetes and hypertensive disease.

Intrapartum

Labor induction. Obesity is associated with an increased likelihood of labor induction. Gross et al[19] reported that 15% of obese women (over 90 kg) had labor induced, compared with 8% of controls ($P<.0001$). Ekblad and

Grenman[20] also showed a significantly higher induction rate in obese patients and those with excessive weight gain during pregnancy.

Cesarean delivery. The effect of obesity on cesarean delivery rates has been debated, but most studies indicate a direct correlation (TABLE 2). Kaiser and Kirby[21] showed that even among low-risk patients in a nurse-midwifery service, a BMI above 29 was associated with a 3-fold to 4-fold increase in cesarean delivery. A study by Cnattingius et al[17] demonstrated that the effect of BMI on cesarean rates also was influenced by maternal height: Short obese women had the highest cesarean rate (36%), followed by (in decreasing order) short, lean women; tall, obese women; and, finally, tall, lean women.

VBAC. These findings raise a natural follow-up question: What is the success rate of vaginal birth after cesarean (VBAC) among obese parturients? Among 30 women weighing more than 300 lb at conception, Chauhan et al[22] noted a VBAC success rate of less than 15%. This is much lower than the general success rate of 60% to 80% quoted in the ACOG practice bulletin on VBAC.[23] Grobman et al[24] reported that VBAC is cost-effective among women with 1 prior cesarean delivery only if the success rate is above 40%; it is therefore worth pondering whether VBAC should be attempted in overweight patients.

Postpartum: Longer hospitalization

Although they did not provide the reasons, Hood and Dewan[25] linked obesity with prolonged postpartum hospitalization. They found obese patients to have significantly longer hospital stays, regardless of the type of delivery:

- Following vaginal delivery, postpartum hospitalization was 3.8 ± 2.4 days among overweight patients and 2.9 ± 2.1 days among controls.
- After cesarean delivery, obese patients were in the hospital for 7.3 ± 5.0 days; nonobese, for 5.4 ± 3.1 days.

One study found the use of a subcutaneous drain or subcutaneous suture decreased the rates of wound infection or separation among obese women undergoing cesarean.

Cesarean complications

Obesity is a specific risk factor for several operative complications, including hemorrhage during surgery, postoperative wound infections, aspiration, and pulmonary embolism. A case-control study by Naef et al[26] revealed that a weight of more than 250 lb has an odds ratio of 13.1 (95% confidence interval, 1.7 to 102.7) for hemorrhage (decrease in hematocrit of 10% or greater, estimated blood loss greater than 1,500 mL, or packed red blood cell administration) during abdominal delivery.

Multiple studies have shown obesity to be a risk factor for postoperative wound infections.[27-30] For example, Johnson et al[30] reported a wound infection rate of 37.6% for the obese parturient and 10.2% for those of normal weight ($P<.001$).

The link between excess weight and infectious morbidity may be secondary to the increased subcutaneous tissue layer and accumulation of loculated fluid. In 2000, Vermillion et al[31] published a study that looked at 140 women who had cesarean deliveries. Initially, a univariate analysis identified the risk factors for wound infection as maternal weight (a mean of 82.8 kg ± 18.6 kg in the uninfected population versus 99.4 kg ± 33.3 kg in the infected population), BMI (44.5 ± 2.1 for uninfected versus 49.7 ± 6.3 for infected), and thickness of subcutaneous tissue (2.3 cm ± 1.2 cm for uninfected versus 4.1 cm ± 1.8 cm for infected). After a multiple logistic regression analysis, however, subcutaneous tissue thickness was the only significant risk factor confirmed. A potential explanation for this finding is that the blood supply to subcutaneous fat is relatively poor.

CONTINUED

Reducing infection. By modifying surgical techniques, physicians may be able to decrease the rate of wound infection among overweight parturients. Naumann et al[32] randomized closure versus nonclosure of the subcutaneous tissue in 245 patients with at least 2 cm of adipose tissue. There was a significant difference in the incidence of overall wound disruptions (14.5% versus 26.6%)—specifically, seroma formation (5.1% versus 17.2%)—between the closure and nonclosure groups, respectively, but no significant difference in wound infections (6% versus 7.8%).

There is no consistent evidence that obesity alone is associated with poor perinatal outcome.

Allaire et al[33] showed that the use of a subcutaneous drain or subcutaneous suture decreased the rates of wound infection or separation among obese women undergoing cesarean delivery. The incidence dropped from 30.8% when neither was used to 15.4% with suture and 4.2% with a drain.

While several investigators have noted the increased rate of postoperative complications among obese parturients, few have systematically analyzed their etiology. Wolfe et al[34] reviewed the antepartum and intrapartum variables among 107 consecutive obese parturients (all at least 200 lb) who had cesarean deliveries. Using multivariate analysis, the investigators noted that various degrees of obesity, preexisting medical conditions, the type of skin incision, and the type of anesthesia were not risk factors for postpartum infectious sequelae. Only 2 factors—both of which were under the control of physicians—contributed to morbidity: duration of cesarean delivery and operative blood loss. According to their regression equation, if surgical time was decreased from 1.5 hours to 1 hour, the postoperative stay would decrease by 1 day. These authors did not comment on the estimated blood loss or drop in hematocrit threshold that would minimize postoperative complications.

What about the neonate?

Interestingly, there is no consistent evidence that obesity alone is associated with poor perinatal outcome. A case-control study by Perlow et al[35] reported the outcomes of 111 neonates born to obese mothers. These infants were more likely to weigh less than 2,500 g or more than 4,000 g, to have intrauterine growth restriction, and to require admission to a neonatal intensive care unit. However, when patients with prepregnancy diagnoses of chronic hypertension or insulin-requiring diabetes mellitus were excluded, perinatal outcome was similar for obese and nonobese mothers. Garbaciak et al[36] reported similar results: They showed that only obese patients with antepartum complications had an increase in perinatal mortality. Two other studies showed no increase in perinatal morbidity or mortality among obese subjects.[19,27] It seems, therefore, that the risk for adverse perinatal outcomes may be related to underlying medical diseases rather than excessive weight.

Research has also linked infant birth weight to maternal weight. Studies have shown the incidence of macrosomic infants (birth weight of at least 4,000 g) to be higher in obese women, even in the absence of antenatal complications.[19,25,36] Specifically, Gross et al[19] concluded that the increase in macrosomic and large-for-gestational-age infants (defined as over 90% of weight for gestational age) born to obese mothers cannot be explained by the presence of maternal diabetes. They noted that the frequency of macrosomia was 15.1% and large-for-gestational-age was 31% among obese patients, while the incidence of diabetes mellitus was only 9%. However, Perlow et al[35] demonstrated that the increased rate of macrosomia disappeared if patients with preexisting medical conditions were excluded.

CONTINUED

Studies also have shown that newborns of obese patients have weight problems as they age. Edwards et al[27] noted that at 1 year, infants of obese mothers were significantly more overweight than those of controls. Specifically, 47% of the infants of obese mothers were above the 75th percentile for weight-length, compared to 22% in the control group.

Counsel weight reduction

Obesity is a major health risk for both the general and obstetric populations. Fortunately, this risk can be addressed through lifestyle modification. Though we lack studies demonstrating improved peripartum outcomes with weight reduction, there is no reason to doubt that weight loss will decrease the rate of adverse events. Ob/Gyns caring for obese patients should inform these women of the unfavorable pregnancy outcomes secondary to excessive weight and encourage preconception weight control. ■

REFERENCES

1. Lu GC, Rouse DJ, DeBard M, Cliver S, Kimberlin D, Hauth JC. The effect of the increasing prevalence of maternal obesity on perinatal morbidity. *Obstet Gynecol.* 2001;185:845-849.
2. Mokdad AH, Serdula MK, Dietz WH, Bowman BA, Marks JS, Koplan JP. The spread of the obesity epidemic in the United States 1991-1998. *JAMA*. 1999;282:1519-1522.
3. *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report*. Bethesda, Md: National Heart, Lung, and Blood Institute; June 1998:1-226.
4. American College of Obstetricians and Gynecologists. *ACOG Education Bulletin #229: nutrition and women*. Washington, DC: ACOG; 1996.
5. Institute of Medicine subcommittee on nutritional status and weight gain during pregnancy. *Nutrition During Pregnancy*. Washington, DC: National Academy Press; 1990.
6. Cogswell ME, Serdula MK, Hungerford DW, Yip R. Gestational weight gain among average-weight and overweight women—what is excessive? *Am J Obstet Gynecol*. 1995;172:705-712.
7. Edwards LE, Hellerstedt WL, Alton IR, Story M, Himes JH. Pregnancy complications and birth outcomes in obese and normal weight women: effects of gestational weight change. *Obstet Gynecol*. 1996;87:389-394.
8. Parker JD, Abrams B. Prenatal weight gain advice: an examination of the recent prenatal weight gain recommendations of the Institute of Medicine. *Obstet Gynecol.* 1992;79:664-669.
9. Isaacs JD, Magann EF, Martin RW, Chauhan SP, Morrison JC. Obstetric challenges of massive obesity complicating pregnancy. *J Perinatol.* 1994;14:10-14.
10. American College of Obstetricians and Gynecologists. *ACOG Technical Bulletin #200: diabetes and pregnancy*. Washington, DC: ACOG; 2000.
11. American College of Obstetricians and Gynecologists. *ACOG Practice Bulletin #29: chronic hypertension in pregnancy*. Washington, DC: ACOG; 2001.
12. Baeten JM, Bukusi EA, Lambe M. Pregnancy complications and outcomes among overweight and obese nulliparous women. *Am J Public Health*. 2001;91:436-440.
13. Stone JL, Lockwood CJ, Berkowitz GS, Alvarez M, Lapinski R, Berkowitz RL. Risk factors for preeclampsia. *Obstet Gynecol*. 1994;83:357-361.
14. Knight M, Duley L, Henderson-Smart D, et al. The effectiveness and safety of antiplatelet agents for the prevention and treatment of preeclampsia. In: *The Cochrane Library*, Issue 4, 2000. Oxford: Update Software. Search date 1999. Primary sources: Cochrane Pregnancy and Childbirth Group Trials Register, conference proceedings.
15. Atallah AN, Hofmeyr GJ, Duley L. Calcium supplementation during pregnancy to prevent hypertensive disorders and related adverse outcomes. In: *The Cochrane Library*, Issue 4, 2000. Oxford: Updated Software. Search date 2000. Primary sources: Cochrane Pregnancy and Childbirth Group Trials Register.
16. Maeder EC, Barno A, Mecklenburg F. Obesity: a maternal high-risk factor. *Obstet Gynecol.* 1975;45:669-671.
17. Cnattingius S, Bergstrom R, Lipworth L, Kramer MS. Prepregnancy weight and the risk of adverse pregnancy outcomes. *N Engl J Med.* 1998;338:147-152.
18. Huang DY, Usher RH, Kramer MS, Yang H, Morin L, Fretts RC. Determinants of unexplained antepartum fetal death. *Obstet Gynecol*. 2000;95:215-221.
19. Gross T, Sokol RJ, King KC. Obesity in pregnancy: risks and outcome. *Obstet Gynecol.* 1980;56:446-450.
20. Ekblad U, Grenman S. Maternal weight, weight gain during pregnancy and pregnancy outcome. *Int J Gynecol Obstet*. 1992;39:277-283.
21. Kaiser PS, Kirby RS. Obesity as a risk factor for cesarean in a low risk population. *Obstet Gynecol*. 2001;97:39-43.
22. Chauhan SP, Magann EF, Carroll CS, Barrilleaux PS, Scardo JA, Martin JN. Mode of delivery for the morbidly obese with prior cesarean delivery: vaginal versus repeat cesarean section. *Am J Obstet Gynecol*. 2001;185:349-354.
23. American College of Obstetricians and Gynecologists. *ACOG Practice Bulletin #5: vaginal birth after previous cesarean delivery*. Washington, DC: ACOG; 2000.
24. Grobman WA, Peaceman AM, Socol ML. Cost-effectiveness of elective cesarean delivery after one prior low transverse cesarean. *Obstet Gynecol.* 2000;95:745-751.
25. Hood DD, Dewan DM. Anesthetic and obstetric outcome in morbidly obese parturients. *Anesthesiology*. 1993;79:1210-1218.
26. Naef RW, Chauhan SP, Chevalier SP, Roberts WE, Meydrech EF, Morrison JC. Prediction of hemorrhage at cesarean delivery. *Obstet Gynecol.* 1994;83:923-926.
27. Edwards LE, Dickes WF, Alton IR, Hakanson EY. Pregnancy in the massively obese: course, outcome, and obesity prognosis of the infant. *Am J Obstet Gynecol*. 1978;131:479-483.
28. Pelle H, Jepsen OB, Larsen SO, et al. Wound infection after cesarean section. *Infect Control*. 1986;7:456-461.
29. Nielsen TF, Hokegard K. Postoperative cesarean section morbidity: a prospective study. *Am J Obstet Gynecol*. 1983;146:911-916.
30. Johnson SR, Kolberg BH, Varner MW, Railsback LD. Maternal obesity and pregnancy. *Surg Gynecol Obstet*. 1987;164:431-437.
31. Vermillion ST, Lamoutte C, Soper DE, Verdeja A. Wound infection after cesarean: effect of subcutaneous tissue thickness. *Obstet Gynecol*. 2000;95:923-926.
32. Naumann RW, Hauth JC, Owen J, Hodgkins PM, Lincoln T. Subcutaneous tissue approximation in relation to wound disruption after cesarean delivery in obese women. *Obstet Gynecol*. 1995;85:412-416.
33. Allaire AD, Fisch J, McMahon MJ. Subcutaneous drain vs suture in obese women undergoing cesarean delivery. *J Reprod Med*. 2000;45:327-331.
34. Wolfe HM, Gross TL, Sokol RJ, Bottoms SF, Thompson KL. Determinants of morbidity in obese women delivered by cesarean. *Obstet Gynecol*. 1998;71:691-696.
35. Perlow JH, Morgan MA, Montgomery D, Towers CV, Porto M. Perinatal outcome in pregnancy complicated by massive obesity. *Am J Obstet Gynecol*. 1992;167:958-962.
36. Garbaciak JA Jr, Richter M, Miller S, Barton JJ. Maternal weight and pregnancy complications. *Obstet Gynecol*. 1985;152:238-245.
37. Kumari AS. Pregnancy outcome in women with morbid obesity. *Int J Gynecol Obstet*. 2001;73:101-107.
38. Steinfeld JD, Valentine S, Lerer T, Ingardia CJ, Wax JR, Curry SL. Obesity-related complications of pregnancy vary by race. *J Matern Fetal Med*. 2000;9:238-241.
39. Jensen H, Agger AO, Rasmussen KL. The influence of prepregnancy body mass index on labor complications. *Acta Obstet Gynecol Scand*. 1999;78:799-802.
40. Ranta P, Jouppila P, Spalding M, Jouppila R. The effect of maternal obesity on labour and labour pain. *Anaesthesia*. 1995;50:322-326.
41. Pongthai S. Labour and delivery of obese parturients. *J Med Assoc Thai*. 1990;73:52-56.

The authors report no financial relationship with any companies whose products are mentioned in this article.