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REVIEW

Management of Labor and Delivery to Reduce Risk for Cesarean Birth in Women with Obesity

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Abstract

Purpose of review This review provides readers with current management guidelines for labor and birth for individuals with obesity and includes a summary of methods for lowering the risk for cesarean birth. The goal of this review was to examine the evidence for women with obesity having uncomplicated labor courses and to apply the concept of metabolically healthy obesity to cesarean birth reduction.

Recent findings One-fifth to one-third of those in labor will have a pregnancy complicated by obesity. A variety of adipokines produced in excess adipose tissue counteract the normal physiology of labor and increase systemic inflammation. Those with obesity but without co-morbid diseases such as diabetes and hypertension have high rates of uncomplicated pregnancy and birth and lower cesarean section rates, particularly if they are younger and multiparous.

Summary Optimal labor outcomes begin during antenatal care with guidance in appropriate weight gain and regular physical activity. Antenatal education tailored to the obesity class and metabolic health of the client should prepare those at risk for the possibility of early induction of labor, longer labors, and cesarean birth. Individuals with metabolically healthy obesity can safely give birth in low-risk units, particularly if multiparous. A team approach to cesarean reduction is needed, with all providers understanding physiologic support of birth including admission in active labor, physical activity during labor, intermittent auscultation, and patience with the length of labor. Those with obesity deserve labor and birth management that begins with a wholistic health assessment followed by a thoughtful application of national guidelines to reduce risks for cesarean birth while preserving optimal perinatal outcomes.

Keywords Obesity · Intrapartum · Cesarean section · Adipokines · Pregnancy

Introduction

As obesity rates increased over the last 40 years in post-industrial nations, obesity became the most common risk to perinatal health. Obesity increases risks for multiple health disorders. Specifically, during pregnancy, risk increases for gestational diabetes, the hypertensive disorders of pregnancy including preeclampsia and eclampsia, preterm labor, prolonged pregnancy, cesarean birth, and postpartum hemorrhage [1–6]. The historical link between obesity and cesarean section birth is strong with rates of cesarean section birth exceeding 50% in many places [1–6]. Individuals with obesity, particularly those with a BMI exceeding 40, are at greater risk for anesthesia, surgical, and post-operative complications [1–6]. Using the WHO definition of obesity (Table 1), body mass index ≥ 30 [7], perinatal providers developed management guidelines to reduce obesity-related disease and mortality. Research in perinatal obesity grouped all individuals with a BMI ≥ 30 even as the numbers of gravidas in class II and class III obesity increased. Although researchers describe a linear relationship between increasing obesity and poor perinatal outcomes, many individuals with obesity have uncomplicated labor and births. A reduction in cesarean birth limits risk for anesthesia, surgical, and post-operative complications. Using risk reducing treatments unnecessarily may cause psychological harm, cause iatrogenic problems such as unnecessary cesarean sections, and waste health care provider time and resources. This review compares international guidelines for the management of obesity during labor and birth, considers the most appropriate applications of those guidelines, and additional methods

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Table 1 WHO obesity classification by body mass index (BMI) [1, 7]

Obesity class	BMI range
Class I	30–35.9
Class II	36–39.9
Class III	> 40

BMI = weight kg/height m^2

of improving labor and birth outcomes while reducing the risk for cesarean birth for those with obesity.

Background: Obesity and Metabolic Health

White adipose tissue is not an inert energy storage depot but the largest endocrine organ, producing a variety of hormones. The metabolic changes related to obesity and labor fall into three main categories: hyperleptinemia, lipotoxity, and chronic inflammation. White adipose tissue produces adipokines involved in appetite, adipose synthesis, and utilization, including leptin, apelin, ghrelin, visfatin, and adiponectin, with many having significant effects to inhibit cervical ripening and reducing myometrial contractility during labor and the birth process (Table 2). White adipose tissue infiltrated by macrophages, neutrophils, mast cells, T cells, natural killer cells, and B cells also produces inflammatory cytokines including TNF alpha, IL-1b, IL-2, IL-6, IL-12, IFN gamma, elastases, cathepsin G, proteinase-3, and IG antibody. These pro-inflammatory cytokines stop the production of anti-inflammatory cytokines and produce peripheral insulin resistance [8, 9]. Women with obesity have lower levels of estrogen and progesterone than the non-obese indicating dysregulation of the hypothalamic-pituitary–gonadal axis [9]. Adipokines make exogenous oxytocin less effective for labor initiation and stimulation in those with obesity by blunting uterine contractility yielding prolonged pregnancy and longer labors [10, 11•]. Circulating leptin increases with increasing BMI and is produced by the placenta as a growth hormone. In vitro, leptin inhibits collagen degradation, thereby serving in vivo to reduce pre-labor cervical ripening and has tocolytic effects [11•]. Excess adipose tissue also releases excess free fatty acids and reactive oxygen species. Excess systemic free fatty acids and dietary lipids are transported into the cells of non-adipose organs, such as the liver and muscle (myometrium), and are deposited as ectopic fat, generating lipotoxicity. Toxic lipids dysregulate mitochondria, endoplasmic reticulum, and lysosomes. This lipotoxicity has added potential to inhibit effective myometrial contractility [9, 11•, 12–14].

Body mass index is a mathematical comparison of weight to height (kg/m^2) and was designed to describe populations [7]. A range of individual body compositions and adipose deposition patterns weakens the usefulness of the BMI calculation when applied to individuals [7]; however, medical practice has defaulted to BMI to describe body habitus because it is a simple calculation. The World Health Organization uses BMI to categorize weight ranges into normal, underweight, overweight, and obese [7]. These categories were originally used to determine food adequacy in populations but are now the standard categories for weight-based

Table 2 Hormones produced by adipose tissue and effects on labor [8–10, 11•, 12–14]

Hormone	Action	Pregnancy-specific changes and actions
Leptin	• Appetite suppression • Stimulates adipose cell hypertrophy • Increases free fatty acid oxidation	• Secreted by placenta • Leptin receptors decrease with increasing BMI causing leptin resistance • High circulating levels of free leptin in those with obesity • Hyperleptinemia - Stimulates PGE_2 release from placenta and adipose tissue. Increased circulating PGE_2 may blunt tissue response to PGE_2 - Increases deposition of collagen in cervix in late term - Inhibits late term cervical collagen degradation - Tocolytic effect on myometrial cells
Apelin	• Inversely related to increasing BMI • Regulates fluid homeostasis • Associated with insulin resistance	In vitro tocolytic effect on myometrial cells
Ghrelin	• Stimulates insulin release • Involved in satiety	May stimulate myometrial contractions
Visfatin	• Activates insulin receptors	• Increases near onset of labor • Tocolytic effect on myometrial cells
Adiponectin	• Increases glucose uptake • Increases lipid catabolism • Increases insulin sensitivity	• Decreases with increasing BMI • Decreases associated with hyperlipidemia

medical research. For example, the Institute of Medicine gestational weight recommendations are based on prepregnancy BMI and used by all national obstetrical guidelines related to obesity in pregnancy [1–5]. The multiple perinatal risks associated with obesity were applied to all gravidas with a BMI ≥ 30 without an individualized, wholistic assessment of their metabolic health or any previous perinatal outcomes [1–5]. Identifying who is likely to suffer a poor perinatal outcome is the central challenge to labor and birth care. While increased risk has been attributed to all with a BMI > 30, most women with high BMIs will have no perinatal complications.

Individuals with obesity, who have no obesity-related co-morbid disease and healthy perinatal outcomes, may demonstrate the concept of metabolically healthy obesity [15]. This concept has not been added to obstetrical management considerations and has been defined by one research team as, "as systolic BP less than 130 mm Hg, no BP-lowering medication," waist-to-hip ratio less than 0.95 for women and less than 1.03 for men, and no self-reported (i.e., prevalent) diabetes [16••]. These researchers studied two cohorts of adults totaling 386,420: those with markers for unhealthy obesity and those with metabolically healthy obesity. Those with metabolically healthy obesity had no increased risk for cardiovascular disease mortality [16••]. Metabolically healthy obesity is the basis for the Edmonton Obesity Staging System (EOSS) [17]. The EOSS adds metabolic health to the BMI measurement to provide a more wholistic health assessment. Individuals in EOSS Stage 0 have obesity but no metabolic, mobility or psychological disease. Those in EOSS stage 1 have subclinical obesity related disease, such as borderline hypertension and elevated lipids. Obesity-related disease such as diabetes and hypertension are the hallmarks of EOSS stage 2, while adults in EOSS stages 3 and 4 have obesity related organ disease [17, 18]. Initial research developing the EOSS used National Health and Human Nutrition Examination Surveys (NHANES) III (1988–1994) and the NHANES 1999–2004, with mortality follow-up for adults aged 20 years or greater with overweight or obesity through to the end of 2006 showed that death rates were different between EOSS stages when stratified by scores of 0–3, but not when stratified by BMI defined obesity classes alone. In every class of obesity, there were adults with metabolically healthy obesity [17].

Only one Canadian team [19] has published a perinatal application of the EOSS, attempting to predict the risk for cesarean birth in nulliparas undergoing an induction of labor. They recruited 276 women with overweight or obesity and a control cohort included 69 normal-weight women. The overall rate of cesarean delivery was 30.4% for the healthy control cohort. Those in EOSS stages 0 and 1 had cesarean section rate of 35.8% and 29.9%, respectively, with women in EOSS stages 2 and 3 had cesarean section rates of 43.2%, and 90.5% ($p < 0.001$) [19]. Further research is needed to conclusively demonstrate that individuals with metabolically healthy obesity are at lower risk for perinatal complications and cesarean birth than individuals with obesity and co-morbid disease.

Using a population approach with 3,722,477 pregnancies in a meta-analysis of 13 studies, D'Souza et al. [20] found that individuals with BMIs > 40 kg/m were at increased risk for gestational diabetes mellitus [17% vs 3.9%; relative risk, 4.6 [95% confidence interval, 3.6–5.9]), hypertensive disorders of pregnancy (15.9% vs 3.5%; relative risk, 4.6 [95% confidence interval, 3.4–6.0]), and cesarean delivery (47.7% vs 26.0%; relative risk, 1.86 [95% confidence interval, 1.75–1.97]). The authors claimed a linear relationship between BMI and poor perinatal outcomes; however, using the 17% occurrence of gestational diabetes, the most frequent perinatal co-morbidity, 83% of those with class III obesity would not have gestational diabetes. In this study, the authors stratified risks by BMI categories encouraging risk-appropriate application of risk reducing interventions [20].

In a 2019 study [21], researchers in Switzerland found that 7.2% of 324,644 pregnancies were complicated by obesity. The obesity related co-morbidities of interest were hypertensive disorders, pre-existing diabetes, and gestational diabetes. Twenty-seven percent of those with obesity had at least one co-morbidity during pregnancy compared to a 6.6% co-morbidity rate in those without obesity. The fact that 73% of those with obesity had no co-morbid conditions during pregnancy is a notable point. The relative risks for hypertensive disorders were 4.01, pre-existing diabetes 3.83, and gestational diabetes mellitus 3.24 (95% CI). The relative risk of macrosomia (1.96) in women with obesity was almost double regardless of diagnosed. Those with obesity had increased relative risk of failure to progress in labor (1.54), and small increases in risk in prolonged labor (1.07), instrumental vaginal delivery (1.07) and epidural anesthesia (1.07). The authors concluded that obesity contributes its own risk to pregnancy and birth but must be considered along with associated co-morbidities [21].

A London group attempted to identify biomarkers and clinical factors that could be used to predict an uncomplicated pregnancy, labor, and birth by prospectively following 1409 participants, all with a BMI ≥ 30 [22]. Biomarkers included HbA1C, insulin, adiponectin, gGT (gamma-glutamyl transferase), and SHBG (sex hormone binding globulin). Although these biomarkers are not routinely assessed during pregnancy, they are indicators of metabolic health. The researchers identified five independent predictors at 15 + 0 to 18 + 6 weeks' gestation that were associated with an uncomplicated pregnancy and birth: multiparity, young maternal age, normal systolic blood pressure, normal HbA1c levels, and higher adiponectin levels. Women were stratified into 5 groups ranging from most likely to have a complicated pregnancy and birth to

those most likely to have an uncomplicated pregnancy and birth based on the normality of biomarkers. Those without gestational diabetes, preeclampsia and other hypertensive disorders were most likely to have an uncomplicated pregnancy (46–56.2%, $p<0.001$), and a spontaneous vaginal birth (83.7–89.9, $p<0.001$) and had lower rates of preterm birth, and postpartum hemorrhage when compared to those with clinical and metabolic biomarkers for co-morbid disease [22]. The elective cesarean rate for those least likely to have an uncomplicated birth was 22.9% and 24.2 for those most likely to have an uncomplicated birth (p 0.03) while the emergency cesarean section rate was 39.9% for those least likely to have an uncomplicated perinatal course and was 5.8% for those most likely to have an uncomplicated birth ($p<0.0001$) [22]. This again illustrates the point that there are individuals with obesity who do not have metabolic disease. Although the data in this study were not stratified by BMI, gestational diabetes and hypertensive disorders are obesity-related diseases lending support to the consideration of metabolic health when planning to reduce the risk for cesarean birth.It is clear that BMI alone is an insufficient assessment of health, and that thorough evaluation of individual metabolic health is needed to reduce the risk for cesarean section.

Management Recommendations for Labor and Birth

Current international management guidelines for obesity during pregnancy are largely based on care provided by physicians in academic medical centers. One systematic review of 33 international guidelines found that there were numerous, evidence-based guidelines for nutrition and physical activity during pregnancy for those with obesity, but that the few that had labor and birth guidelines and their evidence bases were weak [23]. These reviewers also found that no practice guideline addressed the varied risk for poor perinatal outcomes among individuals with obesity, noting that not all those with obesity need high risk obstetrical care [23]. The guidelines from English speaking nations that address labor and birth are outlined in Table 3 and demonstrate the inconsistencies in labor and birth recommendations for those with obesity. Notably, the guidelines vary in the application of risk-reducing recommendations by obesity class [1–6]. For example, RCOG guidelines recommend continuous electronic fetal monitoring when BMI exceeds 35, but RANZCOG recommends continuous fetal monitoring when BMI exceeds 40 [5, 6]. The labor suite context underpinning these guidelines must be considered. Labor suites in the UK, Australia, and New Zealand are staffed by registered midwives, who are experienced with intermittent fetal monitoring and have a broader scope of practice than registered nurses.

Prenatal Preparation

Prenatal education can assist gravidas with obesity to lower their risk for cesarean birth, this includes informed choice discussions about weight gain in pregnancy, risk for obesity-related comorbid disease and poor perinatal outcomes, induction of labor, and place of birth [1, 2, 6]. These discussions need to be individualized based on prepregnancy BMI and will be most effective when all professionals involved in perinatal care provide consistent, evidence-based guidance including obstetricians, anesthesiologists, midwives, and nurses. Pregnant individuals have two effective actions for lowering obesity-related risks in labor and birth: maintaining a weight gain within the Institute of Medicine guidelines for pregnancy (5–9 kg or 11–20 lbs for those with obesity) [1, 2, 6, 24, 25], and being physically active for a total of 30 min at least 5 days a week. Although few large randomized clinical trials of prenatal weight gain and physical activity are published, regular, moderate intensity activity has been shown to reduce the risk of excessive gestational weight gain [1, 2, 6, 24–27] and unplanned cesarean birth [1–3, 6, 24, 28–30]. In a meta-analysis of studies that investigated the effect of maternal weight gain on pregnancy outcomes, reviewed 5354 studies were reviewed with 23 ($n=1,309$; 136 women) meeting inclusion criteria. In those studies, 47% of women exceeded Institute of Medicine guidelines for weight gain during pregnancy and had increased rates of cesarean delivery (OR, 1.30 (1.25–1.35); ARD, 4% (3–6%) [24]. Authors in a systematic meta-analysis of 2948 studies of exercise during pregnancy found 107 randomized clinical trials, with 10 sufficiently similar for synthesis that included 3160 women. Exercise programs started at least by the second trimester with a variety of exercises occurring three times a week for 35 to 60 min, significantly reduced the risk of cesarean delivery (relative risk = 0.66, 95% confidence interval 0.46–0.96; $p=0.028$) [29]. Furthermore, both optimizing gestational weight gain and regular physical activity reduce the risk for gestational diabetes, a comorbid complicator of perinatal outcomes [1, 2, 6, 25–27, 31].

Labor and Birth Management

Table 3 outlines and compares the most recent obstetrical guidelines related to labor and birth management as written by the Society of Obstetricians and Gynecologists of Canada [2, 3], the American College of Obstetricians and Gynecologists [1], the Royal College of Obstetricians and Gynecologists [5], and the Royal Australian and New Zealand College of Obstetricians and Gynecologists [6]. This section will cover management techniques not fully addressed in those guidelines and other considerations. Management recommendations in the guidelines are written for primary providers: physicians and midwives. However, a team that includes

Table 3 Comparison of international obstetrical guidelines and care recommendations related to labor and birth [1–7]

	Society of Obstetricians and Gynecologists of Canada **SOGC** [2, 3]	**American College of Obstetricians and Gynecologists** **ACOG** [1]	**Royal College of Obstetricians and Gynecologists, UK** **RCOG** [5]	**Royal Australian and New Zealand College of Obstetricians and Gynecologists** **RANZOG** [6]
Antenatal care considerations				
BMI categories used in guidelines	BMI ≥ 30	BMI ≥ 30 ● Obesity class I BMI 30.0–34.9 ● Obesity class II BMI 35.0–39.9 ● Obesity class III BMI 40 or greater	BMI ≥ 30 ● Obesity class I BMI 30.0–34.9 ● Obesity class II BMI 35.0–39.9 ● Obesity class III BMI 40 or greater	BMI ≥ 30 ● Obesity class I BMI 30.0–34.9 ● Obesity class II BMI 35.0–39.9 ● Obesity class III BMI 40 or greater
Health history and physical assessment	Do a detailed health history assessment for cardiac, pulmonary, renal, endocrine, skin system conditions, including obstructive sleep apnea (OSA)	Calculate BMI at first prenatal visit and screen for OSA[c]	Measure height and weight at initial visit, ideally in 1st trimester. Repeat weight at least once a trimester Ensure appropriate cuff size for BP measurement and document in medical records If booking BMI ≥ 40 a moving and handling risk assessment should be carried out in 3rd trimester to determine any requirements for labor and birth. Those with BMI ≤ 40 may also benefit from a moving and handling risk assessment Assessment by qualified professional to consider tissue viability issues and prevention of pressure sores for BMI ≥ 40 during hospitalization Clinicians must be aware BMI ≥ 30 at booking/pre-pregnancy is a risk factor for VTE. Risk assessment should be assessed, discussed, and documented at first antenatal appointment, during pregnancy if admitted or develop intercurrent problems, intrapartum, and postpartum	Height, weight, and BMI should be measured and recorded in the antenatal record at the first prenatal visit
Gestational weight gain in pregnancy	A BMI calculated at the first prenatal visit should guide weight gain and physical activity recommendations using Institute of Medicine guidelines[a] Recommend 5.0–9.1 kg (11–20 lbs) total pregnancy gain[a] Monitor gestational weight gain Include approaches for weight gain management into routine prenatal care	Recommend 5.0–9.1 kg (11–20 lbs) total weight gain[a]	There is a lack of consensus on optimal gestational weight gain. Until more evidence is available, focus on a healthy diet rather than prescribed weight gain targets	Recommend 5.0–9.1 kg (11–20 lbs) total gestational weight gain for singleton pregnancies; 11–19 kg total weight gain at term for multiple pregnancies[a] Rate of weight gain in 2nd and 3rd trimester (kg/week): 0.22 (0.17–0.33)

Table 3 (continued)

	Society of Obstetricians and Gynecologists of Canada **SOGC** [2, 3]	**American College of Obstetricians and Gynecologists** **ACOG** [1]	**Royal College of Obstetricians and Gynecologists, UK** **RCOG** [5]	**Royal Australian and New Zealand College of Obstetricians and Gynecologists** **RANZOG** [6]
Physical activity	Screen with PARMed-X Pregnancy assessment[b] prior to recommending physical activity regimes Recommend walking 11,000 steps per day; specific heart rate ranges based on age Ask about physical activity levels at each appointment			Exercise programs should be continued or started using RANZCOG guidelines
Acetylsalicylic Acid (ASA, aspirin)	Recommended if other risk factors for preeclampsia ASA 75–162 mg daily at bedtime, initiated ideally before 16 weeks, continued until term		ASA 150 mg daily from 12 weeks gestation until birth if more than one moderate risk factor including BMI ≥ 35	Consideration for ASA should be given There is in vitro evidence that very low-dose ASA (60 mg) for preeclampsia prophylaxis is ineffective in those with obesity in pregnancy. Recommend at least 100 mg or 150 mg daily dose
Physician consult	Consult maternal fetal medicine for multiple gestations Consult maternal fetal medicine for pregnancy after weight loss surgery[d]	Consultation with a physician who is experienced with high BMI may be appropriate if the primary provider lacks experience or resources to provide care		
Anesthesia	Offer a pre-labor anesthesia consult Consultation with anesthesia service should be considered for those with OSA because they are at an increased risk of hypoxemia, hypercapnia, and sudden death[c]	Offer a pre-labor anesthesia consult or consult in early labor[c]		Offer a pre-labor anesthesia consult, especially if BMI ≥ 40
Intrapartum care considerations				
Induction of labor (IOL)	Obesity alone is not an indication for induction of labor Recommend delivery be considered at 39–40 weeks with BMI ≥ 40 to reduce risk of stillbirth		Induction of labor at term for those with elevated BMI decreases the likelihood of cesarean section without increasing risk of adverse outcomes; decision should be made on individual basis When macrosomia is expected, IOL may be considered. Discuss options for IOL vs. expectant management	No consensus on optimal timing in absence of comorbidities. Individual health care facilities should weigh the risk of stillbirth while waiting for spontaneous onset of labor against the risks of failed IOL If BMI ≥ 50, offer delivery before due date

Table 3 (continued)

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Elective cesarean section (CS)	In the presence of fetal macrosomia (EFW ≥ 4500 g), consider elective CS		The decision to give birth by planned CS should involve a multidisciplinary approach, taking into consideration the individual's comorbidities, antenatal complications and wishes	
Trial of labor after cesarean section (TOLAC)/ Vaginal birth after cesarean section (VBAC)	When offering TOLAC, consider local resources and ability to offer emergency CS, transportation, anesthetic, and surgical challenges Inform clients about the increased risk for emergency CS and the increased risk for severe maternal intrapartum morbidity[e]	No specific recommendations, however, the inverse relationship between BMI and rate of vaginal birth after cesarean is noted. Higher BMI is correlated with a decreased chance of VBAC	If BMI is ≥ 30 at intake, an individualized decision for VBAC following informed discussion and consideration of all relevant clinical factors should be made Inform client of lower success rates and higher complication rates Individuals should be advised that interpregnancy weight loss increases the likelihood of successful VBAC	Have informed discussion antenatally and make an individualized decision regarding mode of delivery Inform clients they are less likely to have a successful VBAC, while also having increased operative and anesthetic risks in event of emergency CS
Setting for delivery			Multiparas and otherwise low risk individuals can be offered the choice to give birth in midwifery-led units with clear pathways for early referral to consultant-led units should the need arise The additional intrapartum risks of maternal obesity and the additional care that can be provided in a consultant-led unit should be discussed with the client to facilitate informed choice about planned place of birth	
Intravenous (IV) access			BMI ≥ 40, IV access should be established in early labor; also consider siting a second cannula	BMI ≥ 40, IV access should be established upon admission to labor ward
Ultrasound for fetal presentation			Ultrasound can be used where external palpation of fetal presentation is difficult or impossible	Consider ultrasound scan at the onset of labor when fetal presentation is unknown or difficult to assess
Intrapartum fetal health surveillance	Recommend continuous electronic fetal monitoring (cEFM) during active labor for BMI ≥ 35 Intrauterine pressure catheter (IUPC) if contractions cannot be otherwise assessed If external EFM fails to detect fetal heart rate, use fetal scalp electrode (FSE)		Use intermittent auscultation until an obstetric indication for cEFM arises	Continuous electronic fetal monitoring in labor is recommended for those with BMI ≥ 40 Those with BMIs of 30–40 may need continuous electronic fetal monitoring in the presence of additional risk factors

Table 3 (continued)

	Society of Obstetricians and Gynecologists of Canada **SOGC** [2, 3]	**American College of Obstetricians and Gynecologists** **ACOG** [1]	**Royal College of Obstetricians and Gynecologists, UK** **RCOG** [5]	**Royal Australian and New Zealand College of Obstetricians and Gynecologists** **RANZOG** [6]
Labor progress	BMI ≥ 35: during cervical assessments, consider lithotomy position and minimizing the number of different examiners Allow for longer first stage of labor before performing cesarean section for labor arrest			
Intrapartum and intraoperative anesthesia		Epidural and spinal analgesia or anesthesia are recommended for pain relief General anesthesia is not contraindicated	Notify on-call OB anesthetist when a person with a BMI ≥ 40 is admitted to the labor ward	Notify operating theater staff regarding admission of anyone whose weight exceeds 120 kg (265 lbs)
Emergencies	Prepare for greater rates of shoulder dystocia in births with high BMI		Active management of third stage of labor is advised for all, especially individuals with a BMI ≥ 30 due to increased risk of PPH	Advise client of increased incidence of emergency cesarean particularly for those with class III obesity At time of vaginal delivery, maintain awareness of the increased risk of shoulder dystocia and postpartum hemorrhage (PPH) Use strategies to mitigate risk of shoulder dystocia and PPH Because of the increased risk of PPH, those with a BMI > 40 kg/m^2 should have intravenous access on admission to labor ward and be advised of the benefits of active management of the third stage of labor
Antibiotics	A higher perioperative dose may be beneficial	Recommendations for weight-based dosage difficult to establish and inconclusive[f]	Due to increased risk of infection with BMI ≥ 30, prophylactic antibiotics should be given at the time of surgery	
Incision considerations	Reapproximate subcutaneous tissue layers at time of CS to reduce wound complications	The optimal method for skin incision has not been determined Subcutaneous drains increase the risk for postpartum infection and should not be routinely used	More than 2 cm subcutaneous fat should have suturing Evidence is lacking to recommend negative pressure dressing therapy, barrier retractors, and subcutaneous drains	

Table 3 (continued)

	Society of Obstetricians and Gynecologists of Canada **SOGC** [2, 3]	**American College of Obstetricians and Gynecologists** **ACOG** [1]	**Royal College of Obstetricians and Gynecologists, UK** **RCOG** [5]	**Royal Australian and New Zealand College of Obstetricians and Gynecologists** **RANZOG** [6]
Venous thromboembolism (VTE) prophylaxis	Postoperative thromboprophylaxis is recommended. Use the appropriate dosing for the given BMI Mechanical thromboprophylaxis should be started before cesarean section and used after	Pneumatic compression devices should be applied prior to cesarean delivery and continued postpartum for all those not already receiving chemothrombopro-phylaxis Consider pharmacological thromboprophylaxis in addition to pneumatic compression[g] Encourage early mobility postpartum	VTE prophylaxis is discussed in general, not specific to cesarean section Consider antenatal and post-birth thromboprophy-laxis in accordance with existing RCOG VTE guidelines Manage acute VTE as per existing RCOG guidelines	VTE prophylaxis is discussed in general, not specific to cesarean section Follow local guidelines for VTE prophylaxis Use standard dose enoxaparin 40 mg daily for 50–90 kg (110–198 lbs), 60 mg daily 90–130 kg (110–286 lbs), or 80 mg daily > 130 kg (286 lbs)

[a]Institute of Medicine recommendation. Weight gain less than recommended is associated with SGA infants

[b]Health Canada. PARmed-X for pregnancy: physical activity readiness medical exam. Accessed 29 July 2022 from https://ywcavan.org/sites/default/files/assets/media/file/2021-01%20/parmed-xpreg.pdf

[c]OSA—obstructive sleep apnea. During health history taking, inquire about snoring, excessive daytime sleepiness, witnessed apneas, or unexplained hypoxia

[d]Potential complications in pregnancy post weight loss surgery include dumping syndrome, increased risk of gastrointestinal bleeding, severe anemia, small bowel volvulus, obstruction, and subsequent internal herniation

[e]Higher BMI associated with decreased rate of unsuccessful TOLAC. Maternal morbidity associated with increased prevalence of anesthetic and operative difficulties in those with an increased BMI

[f]Lack of evidence demonstrating different adipose tissue concentrations of antibiotics or decreased surgical site infections with higher antibiotic dosages

[g]Low molecular weight heparin is recommended by American College of Chest Physicians. Optimal dose not determined; weight-based dosing probably more effective than BMI-stratified dosage strategies for individuals with obesity class III

nurses, anesthesiologists, doulas, and others provides care for those in labor. All team members need to be familiar with each other's roles, scope of practice, and labor support techniques so that the deployment of labor-supporting techniques is confident and consistent.

Kerrigan performed a qualitative study in the UK with 24 obstetrical informants including obstetricians, anesthaetists, and midwives. Key emerging themes included the medicalization of birth for those with obesity and a focus on obesity-related risks. Primary providers described care of those with obesity in labor as challenging with contradictory opinions and methods. Kerrigan urged a positive and proactive approach to the use of labor guidelines so that labor can be optimized for those with obesity [32].

Appropriate Level of Care

International research published by midwives in the last decade demonstrates that perinatal risk varies among those with obesity and that more individuals with obesity have healthy perinatal outcomes than poor outcomes. Although midwifery care focuses on those with uncomplicated pregnancies, midwives also provide care during complicated pregnancies where a system of referral to higher levels of care exists. Thus, midwifery hospital caseloads are of mixed risk and generalizable to other obstetrical studies. An example of this comes from a secondary analysis of data from a prospective cohort study of 1369 women from the Netherlands was published in 2014. Women were eligible for midwife-led care (no co-morbid disease) and groups were stratified by BMI using WHO groups (Table 1) [33]. Women in class I obesity had fewer midwife-led births (OR 0.49, 95% CI 0.29–0.84). They were referred more frequently for hypertensive disorders (4 versus 14%) and prolonged labor (4.6 versus 10.4%) when compared to women of normal weights. Women in obesity classes II and III had fewer midwife-led pregnancies than women of normal weights (OR 0.38, 95% CI 0.21–0.69); however, 55% of those women remained in midwifery care through pregnancy and 30% had a midwife as the primary birth attendant. The women in all obesity classes had no more urgent referrals and no more adverse outcomes than women of normal weights. The authors concluded that midwives could screen for risk and safely assign women to the appropriate level of obstetrical care [33].

A prospective cohort study of English obstetric units followed 17,230 otherwise healthy women with the only risk factor being obesity [34]. Compared to the low-risk women in normal weight ranges, those with class II or III obesity had an increased risk for augmentation of labor, cesarean birth and other adverse outcomes, but a composite of those adverse outcomes showed a small, clinically insignificant increase in risk (adjusted RR 1.12, 95% CI 1.02–1.23). A surprising outcome was that multiparous women with class II or III obesity had a lower absolute risk of the composite adverse outcome and was less likely to require obstetrical intervention than nulliparous women in normal weight ranges (21% versus 53%) [34].

Place of Birth

An informed consent discussion early in pregnancy needs to occur regarding place of birth. A wholistic assessment reviewing safe place for the individual with obesity needs to include metabolic health, parity, and the availability of bariatric equipment for surgery when needed. These discussions are difficult when gravidas with obesity reside in rural areas, where surgical and anesthesia support may be limited or unavailable. Safe birth planning may include travel and possible relocation to a higher level of care before the birth given the higher rate of cesarean birth for those with obesity. The RCOG [5] supports midwifery led care for multiparas and low risk individuals where obstetrical consultation is available. Studies support low-risk settings for birth for those with metabolically healthy obesity [21, 32–37, 38••].

Researchers in Canada performed a prospective cohort study using Ontario birth registry data from 117,236 women, finding that 17.7% were obese [38••]. Of those with obesity, 20.6% had pre-existing co-morbid disease or early pregnancy complications. Women with normal weights and no complicating factors proceeded to have an uncomplicated pregnancy while 58.2% of those with obesity and no other complications had uncomplicated pregnancies. Those with obesity were more likely to have uncomplicated pregnancies if they were younger and multiparous. These authors concluded that those with obesity and no other co-morbid disease could plan birth in low-risk settings [38••]. This study did not examine cesarean section rates.

British researchers carried out a national prospective cohort study of women giving birth of 122 alongside, midwifery-led birthing units [36]. Severe obesity was defined as a BMI > 35 with 90% of that group having a BMI between 35.1 and 40 kg/m2 (class II obesity). Those with severe obesity were compared to women of normal weights. Multiparas with obesity were no more likely than women of normal weights to have augmentation of labor, instrumental birth, cesarean section, maternal blood transfusion, 3rd- or 4th-degree perineal lacerations or admission to an obstetrical unit (5.6% vs. 8.1%, aRR = 0.68, 95% CI 0.44–1.07). Nulliparas with class II obesity had a 67.9% rate of uncomplicated vaginal birth and multiparas with class II obesity had a 96.3% uncomplicated vaginal birth rate, leading the authors to conclude that healthy individuals with BMIs ranging from BMI 35.1–40 kg/m2 have no significant risk associated with planning a birth for a midwifery-led, alongside unit [36].

The USA does not have routinely accessible midwifery care as exists in the UK, Australia, and New Zealand; however, studies of individuals with obesity receiving primary midwifery care show safe outcomes with cesarean sections rates lower than many other studies [32–37]. A study of women with obesity enrolled at freestanding birth centers in the USA [37] did a propensity match of 964 primiparous women with and without obesity finding no significant differences in prolonged stages of labor, rupture of membranes greater than 24 h, or postpartum hemorrhage. Women with obesity who started labor at a birth center had a 30.7% transfer to hospital rate, mainly for pain relief. Those with obesity, including both those who gave birth in the birth center or in a hospital, had an 11.1% cesarean birth rate. Appropriate use of low-risk settings for birth may be a method of reducing cesarean sections in those with obesity.

Labor Admission

Avoiding hospital or birth center admission too early in the labor process adds to the success of labor management. Because cervical dilation and the onset of effective contractions are delayed in obesity, patience is required in the diagnosis of active labor. Zhang's contemporary retrospective study reviewed 228,668 US births recorded from 2002 to 2008, finding that dilation from 4 to 6 cm was slower than previously documented, with progress from 4 to 5 cm sometimes taking as long as 6 h with an additional 3 h to progress from 5 to 6 cm [39]. Zhang's group suggests that 6 cm instead of 4 cm may more accurately define the start of actives labor and they concluded that "allowing labor to continue for a longer period before 6 cm of cervical dilation may reduce the rate of intrapartum and subsequent repeat cesarean deliveries in the USA" [39, 40]. Zhang's study did not stratify labor curves by BMI categories. By 2002, the first year in Zhang's dataset, the adult obesity rate in the USA had reached 31% [41]. Studies have shown that obesity in nulliparas and multiparas is associated with a prolonged first stage of labor; however, in a US study of 118, 978 gravidas this prolongation amounted to only 1.2 h spread over increasing BMI ranges from normal weight to class 3 obesity [42, 43].The rise in obesity in the USA since 1980 may contribute to Zhang's recommended labor curve adjustments.

A before and after study investigating the effect of changing the threshold for failure of labor progress that followed 6,351 women in France demonstrated that when the definition of active labor changed from 4 to 6 cm, the overall cesarean section rate fell from 9.4 to 6.9% [43]. The decrease in cesarean births was driven by a significant decrease in the diagnosis of first stage labor arrest in nulliparas with decreased but insignificant changes in arrest of labor in the second stage and failed inductions of labor [44]. This study did not examine outcomes by obesity class.

Providers and staff admitting the gravida with obesity in labor need to do a wholistic assessment that is based on more than BMI. A metabolically healthy multipara who is 5 feet 11 inches tall with a BMI of 35 will have different labor admission needs than a primipara of the same height and BMI but who also has gestational diabetes and preeclampsia. Labor units might consider mapping a walking path around the building and grounds for those who present with early labor contractions, but are not yet in active labor, and live an inconvenient distance from the facility. Hydration and energy needs also require consideration when early labor is prolonged and hospital admission is deferred until active labor has been achieved [45].

Induction of Labor

The small but significant increase in stillbirth in some with obesity prompts the consideration of induction of labor (IOL) at 39 weeks [2, 3, 6]. The effect of many adipokines to retard cervical ripening and reduce uterine contractions (Table 2) prolongs the induction of labor process. Carlson [35] described the reduced response to labor-stimulating medications and interventions in those with obesity compared to those of normal weights. A propensity match compared 360 nulliparas with spontaneous labor managed by certified nurse-midwives (CNMs) or obstetricians. Unplanned cesarean birth rates, postpartum hemorrhage, maternal intrapartum fever, and neonatal intensive care unit admission were similar between midwifery and obstetrical management. Operative vaginal birth rates were 87.0% lower (adjusted odds ratio [aOR], 0.15; 95% confidence interval [CI], 0.06–0.41) for those cared for by a CNM. Midwifery clients were 76.3% less likely to have third- or fourth-degree perineal lacerations (aOR, 0.31; 95% CI, 0.13–0.79) which may be associated with fewer operative vaginal births. Most importantly, CNM patients were significantly less likely than patients of obstetricians to have labor anesthesia, synthetic oxytocin augmentation, or intrauterine pressure catheters [35].

Clinicians may consider using non-pharmacological methods such as foley catheter ripening first, misoprostol next, then oxytocin for induction of labor. Primary providers need to consider the effects of adipokines on labor physiology and use patience with the process [10]. Assuring adequate rest, activity, hydration, and caloric energy during a prolonged IOL supports the needed physiologic changes [46]. Clients with obesity should be prepared antenatally for the extra length of time for an IOL [10] which sometimes progresses over 2 to 3 days. Having realistic expectations about an IOL prepares the client for patience with a prolonged induction process.

Fetal Monitoring

A BMI ≥ 30 kg/m^2 does not necessitate continuous fetal monitoring as long as the fetal heart rate can be heard for monitoring. Adipose deposition varies widely, not always limiting auscultation of the fetal heart rate. The first attempts at fetal monitoring should be with intermittent auscultation [45, 46]. The RCOG and RANZCOG guidelines suggest electronic fetal monitoring when a BMI exceeds 35 and 40 kg/m^2, respectively [5, 6]. Mobile monitoring devices are ideal so that those in labor are able to walk and sit up at the bedside as much as possible. Fetal scalp electrodes may provide the best the fetal heart monitoring when adipose deposition limits abdominal auscultation or positioning of the Doppler transducer belts. Being able to clearly visualize fetal heart rate patterns may give providers the confidence to continue labor support toward a vaginal birth rather than moving toward cesarean section.

Augmentation of Labor, Patience with Labor Curves

Patience is needed with the application of labor curves. Those with obesity tend to have longer labors [42, 43, 47]. Some speculate that the rise in obesity in the USA since 1980 may contribute to the differences in labor progression observed in contemporary data. The lowered uterine response to oxytocin prolongs stage 1 labor [48] and has resulted in higher doses of oxytocin used in those with obesity before an adequate contraction pattern is achieved [3, 10, 35, 43, 47]. Carlson found that the total dose oxytocin and the duration of administration for labor augmentation increased in a stepwise manner with increasing BMI, but this sample was too small to demonstrate statistical significance [10]. Individuals in this study with class 3 obesity required 35% higher doses of oxytocin during labor than those with class 1 obesity [10].

Mobility During Labor

A frequent weight-based bias assumes that those with obesity are physically inactive and should rest in bed during labor. As long as the person in labor has no mobility limitations, wants to ambulate, or move around the labor area, and the fetus can be adequately monitored, mobility with frequent position changes should be encouraged [35, 45, 46]. The RCOG and RANZCOG guidelines [5, 6] suggest IV access when BMI exceeds 40 instead of universal IV access. The absence of an IV line and fluid bag holding apparatus encourages mobility. Ambulation during labor has been shown to significantly reduce the length of labor and the rates of surgical birth [35, 45, 46].

Cesarean Section

Gravidas with BMIs in the obese range have a higher incidence of cesarean section than those in normal BMI ranges [1–7]. In a metanalysis of 3,722,477 pregnancies, researchers in Canada found that the incidence of planned cesarean birth rose with increasing BMI, with a 17.33% rate in the normal BMI group, 22.5% in class 1 obesity, 24.59% in class 2 obesity, and 29.81% (RR 1.67, 95% CI 1.53–1.82) in class 3 obesity. The rate of unplanned cesarean birth was also stratified by obesity class with 18.85% in class 1 obesity, 20.20% in class 2 obesity, and 21.72% (RR 1.53, 95% CI 1.10–2.13) in class 3 obesity [38••]. Due to the elevated risk of cesarean surgery, RCOG and RANZCOG [5, 6] recommend that anesthesia and surgical teams be notified when an individual with a weight > 120 kg (265 lbs) or a BMI > 40 is admitted in labor. The SOGC and ROCG [2, 3, 5] recommend the prophylactic use of antibiotics to ameliorate the higher risk of postoperative infections. The SOGC and RCOG [2, 3, 5] recommend closure of subcutaneous layers during surgery with AGOC [1] warning against the use of surgical drains as they might increase postoperative infections. All international guidelines recommend the use of post-operative embolism prevention with alternating compression devices and a consideration of anticoagulants [1–6].

Vaginal Birth After Cesarean

Obesity itself is not a contraindication for labor following a cesarean birth [1], but individuals should be realistically prepared for the higher trial of labor failure rate in those with obesity and increased morbidity [1–6]. The availability of appropriate bariatric supplies, a rapid decision to incision time, and anesthesia services are key components to safe trials of labor for those with obesity. While some studies show no association between obesity and successful VBAC, two studies document increased rates of morbidity including scar dehiscence, postpartum hemorrhage, neonatal injury, and prolonged maternal hospital stays for individuals with class III obesity compared to individuals with class III obesity who had elective, repeat cesarean sections [49, 50]. In a study by Hibbard et al. those with class 3 obesity who labored then had a cesarean birth had a sixfold increase in maternal morbidity compared with those who had a successful VBAC (14.2% vs 2.6%, respectively; OR, 6.4; 95% CI, 3.9–10.4) [49]. Maternal morbidity for those with class 3 obesity was doubled when compared with those who had an elective repeat cesarean (7.2% vs 3.8%; OR, 1.9; 95% CI, 1.5–2.6) [49]. Prevention of a primary cesarean section seems a safer strategy for the reduction of cesarean births rather than encouraging those with class 3 obesity to attempt a vaginal birth after cesarean section.

Conclusion

Optimal labor and birth outcomes and a lowered risk for cesarean birth begin during antenatal care with guidance in appropriate weight gain and regular physical activity. Antenatal education tailored to the obesity class and metabolic health of the client should prepare those at risk for the possibility of early induction of labor and longer labors. Individuals with metabolically healthy obesity can safely give birth in low-risk units, particularly if multiparous. A team approach toward reduction of cesarean sections is needed, where all labor providers understand physiologic support of birth. Cesarean section reducing labor management includes admission in active labor for a spontaneous labor onset, physical activity, intermittent auscultation, and patience with the length of labor. One-fifth to one-third of those in labor will have a pregnancy complicated by obesity. They deserve labor and birth management that begins with a wholistic health assessment followed by a thoughtful application of national guidelines to reduce risks for cesarean birth while preserving optimal perinatal outcomes.

Compliance with Ethical Standards

Conflict of Interest The author declares that she has no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any new studies with human or animal subjects performed by the author. A cited, previously published study performed by Jevitt et al. had ethical approval by the Yale University Institutional Review Board.

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