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Obesity and Pregnancy Outcomes

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Summary

Obesity is considered one of the main risk factors for fertile and pregnant women. According to world health organization the prevalence of obesity has doubled in the last 30 years. The following narrative review covers adverse effects of obesity on mother and offspring; hence an adequate management of obesity will be recommended.

Obese women are at higher risk for multiple adverse pregnancy outcomes including thromboembolism, gestational diabetes, miscarriage, stillbirth, postpartum depression, postpartum hemorrhage, and difficulties with breastfeeding. But obesity also effects the unborn child. They are more likely to be either large or small for gestational age, experience fetal distress and are more likely to be admitted to neonatal intensive care units.

Those complications and comorbidities are closely related to pathophysiological changes during pregnancy. In obesity the first anabolic state is missing, leading to insulin resistance early in pregnancy causing hyperinsulinemia, impaired glucose, and lipid metabolism causing macrosomia. Impaired placental invasion and function due to endothelial impairment plays a major role in small gestational age babies. Hence, close monitoring and clear guidelines are needed. There are several recommendations for the management of obese women before, during and after delivery and pregnancy. Those recommendations include antenatal weight loss, management of comorbidities and the supplementation of high dose folic acid and vitamin D daily. Weight gain should be minimized during pregnancy and close monitoring is recommended to ensure early detection. Vaginal delivery should be emphasized. Breastfeeding and postpartum weight loss must be encouraged.

Keywords

Obesity, pregnancy outcomes, gestational diabetes, hypertensive disorders in pregnancy, preterm birth, stillbirth, macrosomia, cesarean section, preeclampsia

Introduction

In this narrative review the short and long-term outcomes of maternal obesity in pregnancy will be discussed. Furthermore, current guidelines will be assessed and a recommendation for the management of obesity in pregnancy will be stated. Obesity is one of the most common short- and long-term risk factors among modern society. According to World Health Organization the prevalence of obesity among adults has more than doubled in the last 30 years. This has been even more prevalent in the age group 5-19, where numbers have quintupled since 1990. Almost 44% of women are considered to be overweight. (1) In the 2000s obesity prevalence was highest in Lithuania compared to the other Baltic states with 11.5%. At that time obesity was already increasing but the prevalence was highest among

women. (2) Unfortunately, there is no recent data available for the distribution of obesity among Lithuanian women.

Classification	BMI (kg/m^2)	Risk of comorbidities
Underweight	< 18.5	Low (but risk of other clinical problems increased)
Normal range	18.5 to 24.9	Average
Overweight	≥ 25	
Pre-obese	25.0 to 29.9	Increased
Obese class 1	30.0 to 34.9	Moderate
Obese class 2	35.0 to 39.9	Severe
Obese class 3	≥ 40.0	Very severe

	Waist circumference (cm)	
Comorbidity risk	Women	Men
Above action level 1	≥80	≥94
Above action level 2	≥88	≥102

Figure 1: Classification of Obesity according to WHO (https://www.researchgate.net/publication/11646619_The_Worldwide_Obesity_Epidemic/figures?lo=1&utm_source=google&utm_medium=organic)

Figure one describes the official classification of overweight and obesity using the body mass index (BMI) and waist circumference. BMI is calculated using the person's weight in kilograms, divided by their height, in meters squared. (3) Obesity is considered one of the main risk factors in fertile women. Studies show that there are multiple problems associated with overweight and obesity considering fertility, pregnancy, and overall postnatal outcomes. Antenatal difficulties mainly include infertility and an increased risk for miscarriage. Maternal adverse outcomes are associated with gestational diabetes, hypertension, preeclampsia, and eclampsia. Furthermore, obese women ae more likely to have either preterm birth or the need for induction of labor. Some studies even suggest that those women are more likely to undergo emergency caesarian section than women with an ideal BMI. Operative risks in obesity during caesarian section may include a higher risk for intraoperative aspiration, difficulties with endotracheal intubation and epidural failure. But the mortality and morbidity does not immediately decrease after delivery. Obese women have a higher risk for developing a thromboembolism, postpartum depression or experiencing difficulties with breast feeding and postpartum weight retention. (4–6) Some may even experience difficulties with wound infection and wound healing. An increased risk for postpartum urinary tract infections and genital tract infections may require close postpartum screening. (7)

However, the complications associated with maternal obesity are not only related to the mother but may also affect their offspring. Neonates born by obese women are more often large for gestational age in comparison to those born by normal-weighing women. Macrosomia may be a reason for operative delivery and overall worse delivery outcomes such as maternal and infant trauma. Especially infants that are large for their gestational age have a higher risk for becoming overweight or obese in adolescence and adulthood. Due to increased insulin resistance, chronic inflammation and oxidative stress associated with overweight and obesity, there is a higher prevalence for early placental and fetal maldevelopment. This predisposes the offspring for congenital anomalies, such as spina bifida or cardiovascular defects. (4,6)

Overweight and obesity remain the main risk factor during pregnancy although current guidelines suggest optimizing maternal body weight prior to conception. First-line management of obesity in non-pregnant women includes lifestyle interventions, anti-obesity drugs like phentermine-topiramate or semaglutide, and bariatric surgery, e.g. sleeve gastrectomy or gastric band. Besides that, recent studies suggest a major psychological impact on weight loss. Cognitive behavioral therapy helps patients to set realistic goals, modifying negative body image, teaches eating slowly and brings enjoyment in eating again. (8) Pharmacological and surgical solutions are not considered safe during pregnancy. Thus, dietary changes and increasing physical activity are the only options left, although those may be efficient in limiting gestational weight gain but not effective in minimizing lifestyle-related weight gain and health outcomes for both mother and offspring. Weight loss supported by cognitive behavioral therapy may have an impact on maternal and fetal health outcomes in the future. (9)

This literature review discusses most recent findings concerning short- and long-term outcomes of obese pregnancies, assessing those for gaps in research. Furthermore, the following will cover up-to-date guidelines and evaluating them critically.

Literature selection strategy

For this literature review a search on PubMed and google scholar was conducted as well as relevant articles of peer-reviewed journals (e.g. Springer Nature, Wiley's Obstetrics and Gynecology hub, New England Journal of Medicine) were included. To exclude older articles, the cutoff point was set at 2019. The data collected had to be in correlation with pregnancy outcomes related to obesity. Those were defined as maternal adverse outcomes such as gestational diabetes, hypertensive disorders in pregnancy, impaired cardiac function, anemia, hypothyroidism, Streptococcal B colonization, preeclampsia, eclampsia, caesarian

section (planned and/or emergency) or assisted vaginal birth (either vacuum or forceps delivery). Neonatal adverse outcomes were defined as macrosomia, neurological or cardiac malformation (e.g.: spina bifida, ventricular septal defect), pregnant toxemia, fetal distress, meconium stained amniotic fluid, admission to the neonatal intensive care unit (NICU) or stillbirth. Assessment of long-term postnatal outcome included postpartum depression, maternal and fetal risk for obesity and type 2 diabetes, miscarriage, hypertensive disorders. Furthermore, the articles used in this review were either published in English or an English translation must be available. Obesity had to be clearly defined as BMI >30 kg/m^2, or there needed to be made a differentiation within the study defining overweight as BMI >25 kg/m^2 and obesity as BMI >30 kg/m^2. Studies defining obesity as a BMI >25 kg/m^2 or >27 kg/m^2 were excluded. Further exclusion criteria included studies with an inadequate methodology and unclear or untransparent reporting of methods or results. The use of non-human or in vitro models were not helpful for the purpose of this research. Studies with either a sample size below 20 participants together with case reports and case series as well as letters, editorials, duplicates, redundant publications, and conference abstracts. Studies older than 2019 or without an available full-text excess were excluded as well. Because studies needed to address obesity and its correlation with pregnancy outcomes, exclusion of studies not focusing primarily on obesity in non-pregnant populations were excluded. To cover the pathophysiological changes occurring in obese pregnancies articles published in PubMed, the European Journal of Clinical Nutrition and the European Journal of Medical and Health Sciences were added to this review.

Clinical presentation of disease and pathology

Pathophysiology

Physiological pregnancies can be roughly divided into two main metabolic phases. (10) The first phase prepares the organism for future energy requirements by increasing insulin sensitivity in peripheral tissues. This anabolic state leads to increased glucose uptake into adipose tissue. Weight gain is aided by early pregnancy lipogenesis. (10,11) The catabolic state begins with the third trimester and the utilization of stored energy from maternal adipose tissue. This switch occurs due to decreased insulin sensitivity. Blood test may show increased plasma glucose levels and free fatty acids in peripheral blood. Those physiological changes will eventually lead to hyperinsulinemia and insulin resistance. This will trigger the switch from lipogenesis to lipolysis in late pregnancy due to peripheral and hepatic insulin resistance. (10,11) In non-pregnant population obesity is associated with a mild inflammatory state- This is also true for the pregnant population regardless prior body weight. Nevertheless,

in pregnancy, this state is highly regulated through anti- and pro-inflammatory mechanisms. The pro-inflammatory mechanisms will enable placental implantation and preserve purpose for nutritional and gas exchange. Anti-inflammatory changes start after implantation of the embryo and are responsible to inhibit rejection by the maternal body. (10)

It is well known that adipose tissue functions not only as an energy storage but is a kind of endocrine tissue as well. Adipose tissue secretes adipokines, typically tumor necrosis factor-alpha (TNF-alpha) and interleukin (IL)-6, responsible for the chronic inflammatory state. Another hormone secreted by adipose tissue is adiponectin which is associated with an increased insulin sensitivity and the inhibition of hepatic glucose release. Its mechanisms are mainly cardioprotective through endothelial cell activation, but also closely related to diabetes mellitus and cardiovascular diseases like hypertension. (10,11) Studies found out that obese women have higher levels of IL-6, IL-8, and C-reactive protein (CRP), especially in the first trimester compared to lean pregnant women. Suggesting a high inflammatory state in early pregnancy associated with the release of cytokines by adipocytes and immune cells is accommodated with adipose tissue. Furthermore, those mechanisms have been related to placental insufficiency throughout the whole pregnancy. (10) Recent studies even suggest epigenetic alterations that occur in obese pregnant women initiating histone modifications, altered micro ribonucleic acid (RNA) expression, as well as an impaired mitochondrial function causing a decreased conversion efficiency from methylation to hydroxymethylation within maternal and fetal desoxyribonucleic acid (DNA). (11)

Weight gain during the anabolic state through lipogenesis and expansion of maternal adipose tissue only occurs in lean pregnant women. Women with antenatal obesity are in a state of lipolysis continuously throughout pregnancy leading to hyperinsulinemia and exposure to higher glucose and free fatty acid levels earlier in pregnancy. Studies suggest this to be the main cause of macrosomia due to increased adipogenesis and premature adipogenetic differentiation, leading to an overall higher amount of white adipose tissue. More intrauterine adipose tissue was associated with a higher expression of insulin signaling proteins which may be responsible for insulin resistance later in life. However, different phenotypes are thought to be driven by histone modifications and epigenomes. Alterations in both due to maternal obesity and nutritional habits may be the foundation for transformed DNA methylation. Mice studies suggest that changes in DNA methylation may accumulate over generations causing a phenotype shift towards a higher body weight, increased cardiovascular risk, insulin resistance and hyperlipidemia in offspring and their potential future children. (11)

Early gestation has a main impact on placental growth and development. Impaired glucose and lipid metabolism due to obesity is associated with macrosomia. This is further escalated by increased lipid accumulation in the placenta and thus an increased fetal lipid supply. However, a lipotoxic effect along with pro-inflammatory processes seem to be occurring in obese pregnancies causing maternal and fetal endothelial dysfunction impairing placental invasion. Studies suggest that high glucose levels cause a high availability of adenosine triphosphates (ATP) inhibiting the activation of adenosine monophosphate-activated protein kinase further reducing DNA hydroxymethylation and thus a phenotype shift. The energy balance of humans largely relies on mitochondrial oxidative phosphorylation. In pregnancies to obese women, impaired mitochondrial function within the placenta is causing an impairment in mitochondrial respiratory complexes. This leads to the accumulation of radical oxygen species. Those mechanisms interfere with the main placental functions, energy supply, nutrient and gas exchange, angiogenesis, and villous maturation. An impaired placenta is not able to produce sufficient amount of estradiol and progesterone. (11)

Maternal health outcomes

Gestational hypertension is classified as a systolic blood pressure over 140 mmHg and diastolic blood pressure over 90 mmHg that appears at two separate occasions after 20 weeks of gestation without preexisting hypertensive disease. (12,13) It is well known, that compared to normal weight pregnant individuals, the risk for gestational hypertension in obese increases by two to three times. (10,14) Recently, a study published in 2024 compared 59 obese pregnant women to 14 normal weighing pregnant women found out that pregnant obese women have a different hemodynamic profile, altered cardiac geometry and impaired diastolic indices. For example, obese women show not only a higher blood pressure, but also increased cardiac output and stroke volume throughout pregnancy. An overall thickened ventricular septum and increased left ventricle end diastolic diameter, posterior wall thickness, left ventricular mass and left ventricular mass index indicate a changed cardiac geometry. Those findings are stated to be consistent with the findings among non-pregnant obese population. Patel et al. stated, that a fall in systemic vascular resistance due to peripheral vasodilation and an increased intravascular volume in pregnancy can be caused by an increased cardiac output. To meet increased demands in peripheral tissue, the body adapts by increasing the left ventricular mass and relative wall thickness. (15) Other sources state, that mortality is tripled in obese pregnant women compared to those that are lean due to cardiovascular risk factors. (12)

Preeclampsia is an obstetric emergency and defined as gestational hypertension with proteinuria >300 mg/24h and makes up about 3-5% of pregnancy related complications worldwide. (10,16,17) The mechanism is associated with maternal arterial dysfunction leading to oxidative injury and inflammation following seizures, coma, and eventually maternal and fetal death. Due to its chronic inflammatory state and insulin resistance, obesity is thought to be the second most common cause of preeclampsia. Each increase in BMI 5-7 kg/m^2 is related to a twofold increased risk. (12,18) Another possible pathologic mechanism causing impaired placental function associated with preeclampsia is the damage to endothelial cells through hyperlipidemia leading to vasoconstriction and platelet aggregation. (19–21) Recent studies suggest that vasopressin may play a major role as biomarker in early detection of preeclampsia, because this is characterized as a low-renin hypertensive state and therefore is associated with high vasopressin. (21) Furthermore, Patel et al. found a connection between inadequate cardiac geometry, maternal cardiovascular impairment, and preeclampsia. This was characterized by a hyperdynamic circulation with high cardiac output, decreased peripheral resistance, left ventricular hypertrophy, and reduced diastolic indices. Therefore, the maternal cardiovascular system plays a major role in the development of preeclampsia. (15,17) A study from Jordan conducted in 2023 including 411 pregnant women showed a 3.5 times higher risk for obese women to develop preeclamptic hypertension compared to lean pregnant women. The same study linked obesity with a 2.8 times higher risk for the development of preeclamptic toxemia and a 4.8 times higher risk to develop eclampsia. (22) However, further research for prevention and screening methods is needed.

Previously, obesity was mainly linked to postpartum hemorrhage due to excessive tearing caused by newborns large to gestational age. Postpartum hemorrhage is diagnosed if blood loss exceeds 500ml after spontaneous birth or one liter after caesarian section. (12) Anemia during pregnancy affects 38% of women worldwide. A retrospective cross-sectional study performed on 390 Moroccan women studying the neonatal and maternal morbidity among obese pregnancies. They discovered a higher risk for anemia in obese pregnant women compared to lean pregnant women. (19) Al Hadid et al. even linked antepartum hemorrhage to inadequate thyroid stimulating hormone (TSH) and thyroxine (T4) levels. (22) However, a cohort study performed in Spain including 16 609 pregnant women observing several pregnancy related complications did not find any correlation between obesity and an increased risk for antepartum and postpartum hemorrhage. (18) The underlying pathology is related to gestational diabetes and hyperinsulinemia interfering with coagulation specifically

decreasing quantitative insulin-sensitivity check index (QUICKI) and glucose infusion rate (GIR). (23)

The best-documented complication associated with obesity in pregnancy is gestational diabetes showing a threefold increased risk. (12) Gestational diabetes is defined as a first-time glucose intolerance during pregnancy diagnosed with a fasting blood glucose level ≥5,1 mmol/l or 60min and 120min after 75g oral glucose tolerance test (oGTT) exceeding >10.0 mmol/L and 8.5 mmol/L. (24) In gestational diabetes, glucose uptake by maternal liver and muscle tissue is suppressed due to physiological changes in the signaling pathway to ease glucose transport to the fetus. (12) During the pregnancy related catabolic stage beginning with the second trimester insulin resistance is increased causing an increased hepatic glucose production. This combination of increased glucose production, hyperinsulinemia and insulin resistance interferes with this sensitive balance leading to an impaired fasting glucose reduction. (10,25) Sonagar et al. tested the umbilical cord blood glucose in 166 pregnant women and related a significantly elevated umbilical cord glucose to insulin resistance and maternal obesity showing that gestational diabetes is not only a risk factor for the mother but for the unborn baby as well. Fetal hyperinsulinemia and maternal obesity are thought to be associated with an increased maternal and fetal insulin resistance, maternal BMI and umbilical cord insulin. There is data showing, babies born to obese mothers have a higher risk of epigenetic modifications associated with hyperphagia, accumulation of adipose tissue, dysregulation of energy balance, lipid metabolism and insulin signaling. (23) Furthermore, hyperinsulinemia and hyperlipidemia are associated with several maternal and neonatal complications including raised anthropometric parameters and fetal hypertrophy of the heart. (15,23,26) Other studies could link a 3.5 times higher chance of recurrent miscarriage with insulin resistance and obesity. (19,27,28) Women with obesity are often at higher risk for developing polycystic ovary syndrome putting them at even greater risk for early miscarriage and macrosomia. Its incidence varies between 5-10% in women of reproductive age. (27) Melchor et al. did not find a correlation between obesity and the development of gestational diabetes. However, they argument that other studies suggest a 0.92% increased risk by each one kg/m2 increase in BMI. (18)

As previously mentioned, obesity correlates directly with a mild chronic inflammatory state caused by adipocytes secreting adipokines. Therefore, obese pregnant women have higher levels of IL-6, IL-8, and CRP especially in the first trimester leading to a slightly higher inflammatory state early on in pregnancy. (10) This is associated with cardiovascular impairment due to cytokine release by adipose tissue causing placental dysfunction and

preeclampsia. (15) The release of proinflammatory agents like interleukins and TNF-alpha furthermore interferes with wound healing. Obese pregnant women may experience more wound related complications after birth or cesarean section. This can be avoided by administering a prophylactic antibiotic treatment from a maternal body weight of 120kg with cefazolin 3g within 60min after cesarean section. If the mother is already in labor or membranes have already ruptured, the use of azithromycin is indicated. Additionally, secondary wound infection may be prevented by covering the subcutaneous layer. (10)
Impaired immune system may also be an explanation for the increased probability of a rectovaginal B streptococcal infection during pregnancy. This could also be related to the difficulty maintaining a good hygiene especially as an obese women during pregnancy. (18,29) Currently studies to reduce maternal rectovaginal colonization with group B streptococcus are conducted. For example, Hayes et al. currently test the use of oral probiotics in pregnancy through a double-blind study. They are planning to recruit 450 pregnant women. Half will receive daily oral dose of three different probiotics while the other half will receive a placebo. Between 35th week of gestation and delivery the women will take a vaginal rectal swab analyzing the Group B streptococcus colonization status. Analysis of urogenital infections and maternal antibiotic exposure will be included too. (29)
A study conducted in 2023 on 411 Jordan women suggests obstetrical complications such as postpartum depression, preterm labor and fetal distress may be related to an imbalance in thyroid hormones and obesity. According to this study, obesity is closely related to the development of hypothyroidism during pregnancy. An abnormality in the hypothalamic-pituitary-thyroid axis is associated to higher levels of thyroid stimulating hormone which is particularly common among pregnant women with antenatal extreme obesity. This population seems to suffer from thyroid symptoms, like increased sensitivity to cold or fatigue, more often than pregnant women with a normal antenatal BMI. Furthermore, impaired TSH and FT4 levels suggest a higher probability to suffer from postpartum depression and fetal distress or even death. An imbalance in thyroid hormones seems to be related to preterm delivery, lower birth weight and the development of cerebral palsy. (22)
Another major point discussed in several studies is the higher incidence of performed cesarean sections and assisted deliveries among obese pregnant women. Most studies suggest an almost three times higher risk among obese compared to lean pregnancies. (10,12,30) Obese women also tend to experience labor induction more often than pregnant women with a normal BMI. Furthermore, obese women undergoing labor induction have a threefold risk of emergency cesarean section due to stalled labor. (12,18) One reason for

higher planned and emergency cesarean section rates among obese women may be due to higher incidences of increased anthropometric measurements and macrosomia that require intervention. (23) Obese pregnant women also have more often comorbidities, slower progression of labor and a prolonged pregnancy. Those may all be indications for either induction of labor or cesarean section. Interestingly, Melchor et al. did not confirm an increased occurrence for assisted deliveries in obese pregnancies. (18) A Swedish cohort study however linked a higher BMI to a lower probability to start labor spontaneously and an increased number of assisted deliveries and cesarean sections. They recommended to induce labor earlier especially in women with obesity and other comorbidities. In their study they state that "six babies could have been saved". (20) Additionally, there seems to be a correlation between preterm birth, multiple miscarriages and a higher rate of cesarean sections in obese mothers compared to lean pregnant women. (14,30) However, some studies suggest that the mode of delivery is independent of antenatal BMI but dependent on maternal weight gain during pregnancy, maternal age, and fetal head circumference at delivery. Nevertheless, especially emergency cesarean sections are more common in obese and morbid obese women. On the other hand, Syböck et al. could not identify a direct causality between this mode of delivery and obesity. (30)

Finally, deep venous thrombosis or venous thromboembolism is the leading cause of maternal morbidity and mortality in pregnancy.(31) Among pregnant population deep venous thrombosis and venous thromboembolism seems to occur more often. Different physiologic changes are associated with this including increased blood volume, hormonal changes, changes in blood flow dynamics. This may be exacerbated by the following risk factors, hypercoagulability, multiparity, maternal age over 35 years, obesity, hereditary thrombophilia, a history of deep venous thromboembolism or a history with oral contraception, increasing the risk significantly. (31–33) Studies suggest that in one out of 1000 pregnancies a deep venous thrombosis or venous thromboembolism occurs. (33,34) An Iranian study found out that obesity is the most common risk factor for the development of a venous thromboembolism and second most common indication for a thrombosis prophylaxis. (32) Although the 2019 European Society of Cardiology (ESC) Guidelines on venous thromboembolism (VTE) categorized obesity as a mild risk factor, this is considered not to be true for the pregnant population. A Swedish registry-based cohort study on 1 068 040 pregnant women identified a linear increase of venous thromboembolism risk along with an increased BMI in early pregnancy starting from a mildly elevated BMI. With a BMI over 30 kg/m^2 the risk doubled and with a BMI over 35 kg/m^2 the risk was increased by a fourfold

compared to the women with an antenatal BMI in the normal range. (35) Complications that are associated with a deep venous thrombosis are pulmonary embolism, post-thrombotic syndrome, preterm birth, low birth weight and still birth. Therefore, preventative measures must be taken for pregnant women with multiple risk factors (e.g. obesity) in order to minimize the risk for development of either of the mentioned complications. (31,33)

Fetal health outcomes

As previously mentioned, in obese pregnant women a catabolic state is present from the first trimester instead of the second to third leading to an increased fetal glucose supply and a dysregulation of adiponectin level responsible for fetal lipolysis. Maternal insulin resistance is responsible for maternal high blood glucose levels facilitating the transport of free fatty acids through placental lipase, triggering early fetal insulin production and the deposition of fat and glucose. Furthermore, fetal adipogenesis is disrupted in case of maternal obesity and leads to accumulation of adipose tissue. This mechanism is thought to be associated with augmented fetal growth especially fat mass growth leading to macrosomia. (10,23,36,37) Therefore, many studies propose a significant correlation between a high maternal BMI and the prevalence of newborns large for gestational age. (18–20,23,30) Macrosomia is defined as a birth weight exceeding 4000 grams. (18) Neonates that are not only heavier and larger in body size but also in head circumference are almost twice as common in obese and overweight pregnant women compared to those born to lean pregnant women. This may be the main reason why vaginal tearing and cesarean sections are more common among obese women giving birth. (30) Nevertheless, not only babies born large but also small for gestational age are more prevalent among women with antenatal obesity. This can be related to an impaired placental function and a high fat diet that is more common in obese pregnant women. Fetal growth restriction is one of the main causes of stillbirth. (20,38)

Asian studies suggest that overweight and obesity are associated with a 26% greater risk of miscarriage and every 5 kg/m^2 increase in BMI of above the ideal range increases the risk of stillbirth by 24%. (12) Preconception obesity may play a major role in early miscarriage. (39) Abortions within the first trimester seems to be 1.2 times more common in women with obesity. (19,40) Impaired placental implantation associated with increased leptin accumulation simultaneously occurring with an increased amount of maternal leptin being the major pathological mechanism. (10,12) There are many causes related to preterm birth and stillbirth in obesity. The cardiovascular risk factors include a fetal compromised cardiometabolic profile due to dyslipidemia, endothelial dysfunction and increased maternal blood pressure. Metabolic mechanisms include hyperinsulinemia, insulin resistance and

consequently hyperglycemia. (10) Especially insulin resistance associated with increased fasting plasma insulin and an abnormal glucose to insulin ratio puts mother and fetus at risk for recurrent miscarriage. (28) Low-grade chronic inflammation and infection with, for example rectovaginal streptococcal B, may initiate preterm birth due to the following mechanism. (10) Intrauterine inflammation during labor plays a major role in the physiological onset of labor, promoting cervical ripening dilation, uterine contractility, and excitability. If TNF-alpha and interleukins enter the uterine cavity this may induce preterm labor, this mechanism is seen when pathogens like Ureaplasma Urealyticum enter the uterus. (41,42) Overall, most studies agree that preterm birth is a dose-response relationship and closely related to obesity, while the lowest risk appear to be among normal weight women. (19,20,22,30,43) Melchor et al. appear to be the only research group disagreeing with the significance of obesity and miscarriage. (18) Moreover, obesity is not only related to fetal mortality but accounts for a long-term elevated risk in maternal mortality even despite compliance with weight loss measurements. (43) However, weight loss during pregnancy decreases the risk of stillbirth by 14%. (12)

To determine neonatal status directly after birth, the most used method is the APGAR score developed by Dr. Virgina Apgar in 1952. The APAR score includes the assessment of skin color, heart rate, reflexes, muscle tone and respiration at one minute and five minutes. Every element scores between zero and two, added together they give a total score. A score between seven and ten is considered reassuring, between four and six is moderately abnormal and a score less than three is considered abnormal. With a score below seven at five minutes neonatal resuscitation must be initiated immediately. (44) Fetal distress characterized by an APGAR score less than ten after one, five and ten minutes after birth is more common among obese pregnant women. Because a decreased APGAR score is associated with a bad postnatal adaptation to the extrauterine environment this may be linked to the increased number of babies born to obese mothers that are admitted to the NICU. (18,20,22,30) A decreased APGAR score may be related to macrosomia making it difficult for the baby to adapt. Furthermore, fetal acidosis at birth may play a role in this. Syböck et al. tested the umbilical cord blood of babies born by obese and normal weight mothers. There were major differences found in arterial blood pH but not in the venous blood pH. The arterial pH value decreased with increasing maternal weight status, indicating fetal acidemia due to oxygen deficiency. This mechanism can only be partly related to obesity because acidosis could only be detected within the arterial blood samples. A possible mechanism underlying fetal hypoxia is maternal exertion during labor. Fetal acidosis can be an indication for the admission to the NICU. (30)

There are several adverse outcomes for the offspring that can be related to maternal obesity. While there is no explanation for this mechanism currently, the offspring has a higher risk of developing obesity and insulin resistance later in life. (12) Furthermore, congenital heart defects appear more often in neonates born to mother affected by gestational diabetes. Those include, hypertrophic cardiomyopathy septal defects, aortic arch defects, persistent ductus arteriosus, left ventricular outflow tract obstruction and right ventricular outflow tract defects. (10,12,26,45) Shoulder dystocia is only indirectly related to obesity in pregnancy because this only occurs due to macrosomia associated with increased anthropometric measurements making the child too small for the maternal birth channel. (12,46)

Overall, during the last two decades the average maternal body weight rose by a mean 4.4 kg. This exposes the newborn to major complications due to transgenerational detrimental sequalae. Those may even lead to a decreased life expectancy which is already expected for at least 50% of children affected by the metabolic syndrome which is closely related to diabetes mellitus and obesity. Maternal weight is expected to increase further throughout all age groups. (37,43) Multiparous women have an increased number of risk factors in general compared to primiparous women. Those include not only higher BMI-increase rates and obesity but also tobacco use, lower socioeconomic status, older maternal age, and a high fat diet. Thus, putting their offspring at further risk. (20,43)

Intervention and Management strategies

Obesity in pregnancy requires close monitoring to prevent and control the development of adverse outcomes. In the last decade some Western countries have established guidelines to offer the best care for the mother and her offspring, but there are still no commonly used guidelines. (12,43) However, the oldest guidelines have been established in 2010 by the British national institute for health and excellence (NICE) on the base of weight loss programs already proven useful. (47) They build the cornerstone in the management of obesity in pregnancy. Therefore, they are still useful and need to be acknowledged. All other guidelines included in this review are not older than five years. Akselsson et al. compared guidelines all throughout Sweden compared 21 different health regions and found similar guidelines in 13 of them. Beside the national differences, there are existing national guidelines from the International Federation of Gynecology and Obstetrics (FIGO).

First and foremost, the development of obesity and overweight should be prevented in the first place. (47) This can be done by early education in schools and youth centers about the importance of physical activity and nutrition. It may also be useful to provide teaching to the whole population including advice about the risks of obesity and their short- and long-term

effects. (20,47–49) In addition to that, primiparous women seem to be those with the lowest BMI among pregnant women and prevention of excessive weight gain during pregnancy and interpregnancy weight loss should be promoted. (43)

Antenatal care

Antenatal visits at any healthcare provider (e.g. general practitioner, gynecologist,…) or primary care facility offers the opportunity to assess, monitor and optimize body weight prior to conception. (47,50) Therefore, it is recommended to measure waist circumference, body weight and height and calculate BMI and not use self-reported measurements. (48,49,51) In case of present obesity encourage weight loss through personalized adjustments in lifestyle, diet and physical activity. (47–52) The recommended diet should contain starchy, fiber-rich foods and a low amount of fat. To decrease calorie intake, use portion control and avoid sugar as well as fried, processed foods. A minimum of five portions of fruit and vegetable daily should be consumed. Start the day with breakfast for better glucose control throughout the day. (47) If needed, the patient needs to be referred to a dietician to optimize nutrition. (50) Daily movement should be incorporated into everyday life using the bike or go by foot instead of using the car or public transportation, by minimizing sedentary activities and through daily activities (e.g. swimming, cycling, aerobics). (47,49,52) The aim of weight loss should always be a normal weight or BMI, but weight loss should not exceed 0.5 to 1kg per week. Physicians should educate about obesity risks and benefits of losing weight and support the women during this process. (47,51) Coping mechanisms can be useful for some women to handle situations that might interfere with their weight loss. Physicians need to be aware of sociodemographic, ethnic and cultural differences that interfere with weight loss. (47,48) Many studies show that obesity often comes along with other risk factors, for example tobacco use, lower socioeconomic status, advanced maternal age, high fat diet. Those women may need closer controls and better support during their weight loss journey. (20) Patients with failed attempts to decrease weight or women with obesity class III should be offered pharmacological or surgical intervention. (50,51) Contraception must be ensured during all times of weight loss to prevent adverse fetal outcomes like growth restriction or stillbirth due to nutritious deficiencies. (50,52) After weight loss endorse a period of three to six months weight stabilization before conception. (49) According to German guidelines for the management of obesity in pregnancy, a 12 month period of contraception after bariatric surgery is recommended. (52) Because the average women gains up to two BMI units per pregnancy, interpregnancy weight loss needs to be promoted more. This may help decreasing the risk for pregnancy related hypertensive disorders, stillbirth, and macrosomia. For women

that had previous delivery by cesarean section, interpregnancy weight loss may aid the possibility for vaginal delivery. (49,50)

However, micronutrient deficiency plays an even bigger role in obese pregnancies compared to women with a antenatal normal weight. All guidelines suggest the antenatal supplementation of folic acid to prevent the development of neuronal tube defects. (51,52) Some studies state that requirement of 0,4mg to 5mg daily for prior to conception depending on the women. (51) Due to the lack of evidence, others suggest that 0,4mg of folic acid daily is enough. Altered absorption after bariatric surgery may be an indication for the doubled doses of folate acid according to the German guidelines up to 0,8mg daily. (52) There is not only variation in the dose but also in the period required antenatally, varying between one and three months. (49–52) The FIGO guidelines suggest not only the supplementation of 5mg folate acid but additionally the administration of 150 µg iodine. (48) The assessment of vitamin B12, Vitamin D and iron may be necessary to ensure adequate supplementation. Women who have undergone bariatric surgery need to be monitored for nutritional deficiencies and extra supplementation has to be taken regularly. (48,49)

Present comorbidities that can interfere with a healthy pregnancy must be assessed and managed properly at preconception visits. (52) Pulmonary, renal, cardiac, endocrine, skin, and psychosocial status are thoroughly checked. Patient must be referred to a psychologist or other specialist if needed. (48,51) If they are already treated, the medication must be reviewed and eventually adjusted to pregnancy safe medication. For example, the medication of choice in polycystic ovary syndrome (PCOS) associated with insulin resistance and obesity is metformin. (52,53) A reduction in insulin levels aids in regulating luteinizing hormone and androgen levels and therefore helps in regulating the menstrual cycle and conception. Because metformin crosses through placenta and can be found in breast milk it is only considered second choice after insulin in regulating gestational diabetes. (53) Insulin administration should be considered as first-line treatment concerning gestational diabetes in adequate glycemic control cannot be achieved through lifestyle changes. (54) Hypertension is mainly managed using methyldopa, beta-blockers or nifedipine. (52) Calcium channel blockers like methyldopa or nifedipine have a better effect on gestational hypertension compared to beta blockers. However, careful dose adjustment is curial because they may induce fetal bradycardia, growth retardation and hypoglycemia. If calcium channels blockers are chosen, magnesium sulfate must be avoided due to high risk developing hypertension. During lactation the use of labetalol, nifedipine and enalapril is recommended. (55)

Prenatal care

The first prenatal visit after conception requires the measurement of weight and height and the calculation of the current BMI. It is important to not accept self-reported antenatal measurements to make sure the valuables are accurate. (47,48) Current guidelines do not recommend dieting. Weight must be closely monitored during pregnancy due to the high risk of nutritious deficiency of the unborn child. (47,48) Though, it is recommended to increase the daily calorie intake by 200 to 330 calories some guidelines do not recommend an exact weight range that is considered appropriate. (47,50) A weight gain of five to nine kilogram should be estimated in obese pregnant women which is slightly lower than the weight gain recommended for women with a preconception BMI in the normal ranges. (48,52) Thus, close monitoring of weight gain through weighing and/or BMI calculation must be ensured in obese women. (51) A reevaluation of weight gain through medical staff should be done in the third trimester more specifically in the 36^{th} week of gestation to further evaluate the possibilities and offer the optimal support for the birth. (49,51) Australian guidelines recommend reevaluation of weight gain with a practitioner at least once per trimester and additional measurement around weeks 12 to 14 to ensure appropriate weight gain and monitoring. (50)

To minimize excessive weight gain during pregnancy, the first prenatal visit must include education about healthy lifestyle choices, regular physical activity, adequate diet and nutrient supplementation. (47,48,51,52) Some studies suggest that pregnancy is a very teachable moment especially among pregnant nulliparous women with a high education the compliance seems to be high. However, young nulliparous women with a lower socioeconomic status show the worst compliance among all age groups suggesting that a link between education and maternal body weight exists. (12,50) Appropriate physical activity during pregnancy especially for obese women should include moderate intensity strength and aerobic exercise. If this is impossible, decreasing the amount of sedentary activities and increasing everyday movement (e.g. climbing the stairs, walking, riding a bike) has to be advised. (47,50) A counseling with a dietician can be helpful for women with a BMI above 30 kg/m^2 for further lifestyle advice considering physical activity and recommended weight gain. (47,49,50) Especially obese women should receive early prenatal consultation and screening. This includes baseline screening for nutritional deficiencies (esp. ferritin, vitamin B12 and D, magnesium, folate, potassium), renal and hepatic function tests, protein-creatinine ratio, and a urine dipstick. Additionally to baseline screening the risk of maternal obesity during pregnancy needs to be discussed during those visits. (51) First and foremost, assessment of

maternal blood pressure for hypertension, consider ordering an EKG in case of hypertension. (49,51) Although hypertension is one of the major risk factors all women should receive a screening for preeclampsia from weeks 24 to 32 every three weeks and starting from 32nd gestational week every two weeks. (49) However, others suggest early testing for preeclampsia due to increased release of adipokines, mild chronic inflammation and insulin resistance. They suggest preeclampsia risk calculation for obese women between the 11th and 14th weeks of gestation and if their risk exceeds 1:100 they will require prophylactic treatment with aspirin until the 37th week. (19,51,52) Early screening for gestational diabetes using oral glucose tolerance test in obese pregnancies during the first trimester and repeated between 24th and 28th week of gestation is recommended. (48,50–52) Pregnancies by women with previous bariatric surgery are automatically considered as high risk and require close surveillance of nutrition, blood sugar levels, fetal and maternal screening.(49) They are likely to develop a dumping syndrome. (50,52) This means rapid gastric emptying into the small intestine due to hyperosmolar chyme. Early dumping is associated with a rapid fluid shift from vasculature into the lumen causing an increased volume in the small intestine, being the main cause of abdominal cramps, tachycardia, and nausea. In case of late dumping hyperinsulinemic hypoglycemia occurs a few hours after a carbohydrate meal. This mechanism is still unknown. (56) Therefore, blood glucose levels need to be monitored between the 24th and 28th gestational week for at least four to seven days or to use venous fasting glucose and 24h blood sample glucose profile as diagnostic instrument to detect hypoglycemia. (50,52) However, some guidelines suggest screening, monitoring, and prophylactic treatment of venous thromboembolism in some women with antenatal obesity. Referral to a psychologist should be done as needed after assessment for maternal mental health and psychosocial wellbeing. (49,51) German guidelines suggest some additional screening including serial measurement of progesterone levels and cervix. Uterine arteries are assessed between the 20th and 24th gestational weeks using doppler ultrasound. When performing transabdominal ultrasound is difficult due to increased fat mass consider transvaginal ultrasound for fetal assessments in the first trimester. (52) Moreover, physicasn should screen obese women that experience night time snoring for undiagnosed sleep apnea. This would making intervention necessary. (51)

Fetal screening should include serial measurement for fetal growth between 28th to 39th gestational weeks using transabdominal ultrasound.(48–50) For women with an antenatal healthy BMI the baseline screening tool for fetal growth assessment is symphysis-fundal height, this is highly inappropriate for women with antenatal obesity, especially those with a

BMI above 40 kg/m^2, and ultrasound should be used. (48,51) In obese women, fetal biometry should focus on the fetal abdominal circumference growth velocity for early detection of macrosomia. This allows weight estimation, general anatomical assessment and dating estimation. If transabdominal ultrasound is difficult, reassessment is necessary. (51) Additional fetal biometric exam can be scheduled for obese pregnancies between 34th to 36th week and then weekly reassessment. (52) Altered fetal movements suspect fetal growth restriction or stillbirth. Because the risk for both is higher among obese pregnant women regular fetal assessment is crucial.(48,51) Occurring difficulties need to be communicated openly and other visualization methods must be offered (e.g. magnetic resonance imaging) required for adequate assessment of the fetus. (52) Obesity can make genetic testing at weeks 12 to 14 difficult and has a higher probability for requiring invasive techniques. Chromosomal abnormalities can be detected by using cell-free fetal DNA testing through a blood sample. But awareness is necessary because cell-free fetal DNA decreases with maternal obesity. (48,52)

Supplementation

Supplementation and pharmacological prophylaxis need to be personalized and may require prior blood testing. (51) As mentioned previously, all pregnant women should receive supplementation with folic acid at least throughout the first trimester and vitamin D supplementation throughout pregnancy, because the biological requirements are higher for obese pregnant women. (48–52) Recommended is a vitamin D supplementation of <50 nmol/L daily or 200-600 UL/d. (51,52) Additional calcium and phosphate supplementation can be considered. (52) If risk for preeclampsia is high prophylaxis with 100 to 150mg aspirin daily starting from early pregnancy until the 37th week of gestation is recommended depending on the source. (48–52) Australian guidelines recommend additional administration of 1500 to 2000mg calcium daily until 36th week. (50) Risk for preeclampsia is high when obesity is accompanied by one or more moderate to high risk factors (e.g. advanced maternal age, BMI >35 kg/m^2, first pregnancy, family or personal history with preeclampsia, multiple pregnancy). (48,49) Venous thromboembolism prophylaxis should be adjusted to maternal body weight. For example, a standard dose of 40mg enoxaparin daily with a body weight of 50-90 kg and then increased to 60mg for a maternal body weight up to 130kg. If 130kg maternal body weight is exceeded, 80mg of enoxaparin per day needs to be administered. (50) At high risk for a venous thromboembolism are obese women with an additional risk factor (e.g. history of oral contraception or venous thromboembolism, hereditary thrombophilia, advanced maternal age, long travel, multiple pregnancy). Those women will

require postpartum anticoagulation for at least six weeks. After cesarean section pharmacological and physical prophylaxis is recommended. (52) Always remember to calculate venous thromboembolism for prenatal and postnatal period. (48) Additional nutritional supplementation and monitoring of fetal growth is required for those pregnant women who have undergone bariatric surgery. (48,51,52) Supplementation must be adapted each trimester according to recent blood samples. (52) A referral to a dietician should be offered. (48) Physicians should ensure that vaccinations are up to date including influenza and Covid-19 because obesity is related to complications in both diseases. (50)

All prenatal care institutes should be accessible for obese women and provide clear pathways and guidance. Weight appropriate equipment should always be available. (48) A multidisciplinary approach is recommended. Besides a dietician, involvement of an anesthesiologist, midwife, general practitioner and a lactation specialist is helpful by the time of delivery. (49–51) Some guidelines suggest referral to an anesthesiologist only from a BMI >40 kg/m^2. (48,51,52) On the other hand, Australian guidelines state that with a BMI between 35 and 40 kg/m^2 an additional ultrasound and the referral to a midwife is enough because there is no clear evidence that further examinations are necessary according to current data. (51) Furthermore, Akselsson et al. found a discrepancy within the Swedish regional guidelines for the management of obesity and pregnancy. Only 52% of the regional guidelines used for their literature review indicate a referral of obese women to a midwife. (20)

Delivery

Obese women should be advised to have their baby delivered in a perinatal center regardless of their previous medical history except multiparous women with no additional risk factors. A safe delivery can only be ensured by a multidisciplinary care team including a full surgery team and an anesthesiologist on call. (49,52) They should be informed at the time of admission, especially if the maternal weight exceeds 120kgor a BMI of 30 kg/m^2. (27,29,30) A perinatal center must be prepared for all circumstances. To take optimal care of obese pregnant women, the staff requires a large room with enough space to move around. Even during delivery, the room must be equipped with weight appropriate ward and delivery beds, examination couches, wheelchairs, lifting equipment and spacious toilets. An operating room with adequate operating tables and suitable theater gowns is also recommended. Obese women may require special medical devices and instruments to ensure adequate examination, for example extra-large blood pressure cuffs, weighing scales and extra-long epidural/spinal needles. The medical staff may require specific training for optimal care. (49,52)

Furthermore, early intravenous access with at least one canula is recommended from a BMI >30 kg/m^2 and a second intravenous access should be considered for all women with a BMI >40 kg/m^2. (48–52) Early epidural placement in women with obesity class III is beneficial especially in case of an emergency cesarean section. (48,51) Monitoring of maternal heart rate and blood pressure to control cardiopulmonary stability during delivery is required. (52) If external fetal monitoring is inadequate, continuous fetal monitoring is required. In case of maternal BMI >40 kg/m^2, fetal monitoring must be done using intaurine pressure catheter or fetal scalp electrodes. (48–52) Some consider intrapartum fetal monitoring starting from a maternal BMI >30 kg/m^2. (48,50) This is the most appropriate way to identify fetal stress early and interfere if necessary. (52)

Labor induction is controversial among obstetricians and gynecologists. Some recommend labor induction from 41st gestational week in women with obesity class III. (48) Other studies recommend induction in week 41 already from a BMI over 30 kg/m^2 and a maternal age older than 35 years to decrease the likelihood of stillbirth. (20) Labor induction at term or from 39th gestational week in women with obesity class I and at least one additional risk factor may decrease birth related complications and emergency cesarean sections. (49,51,52) Australian guidelines advise preterm labor induction and delivery only for women with a BMI >50 kg/m^2. (50) Most common risk factor indicating preterm labor induction is macrosomia. However, labor induction fails more often in obese pregnant women compared to lean pregnant women but may decrease cesarean section rates. There are no clear guidelines nor studies providing further information. In obesity the recommended medication for labor induction is oxytocin due to highest success rates. (51)

Cesarean section

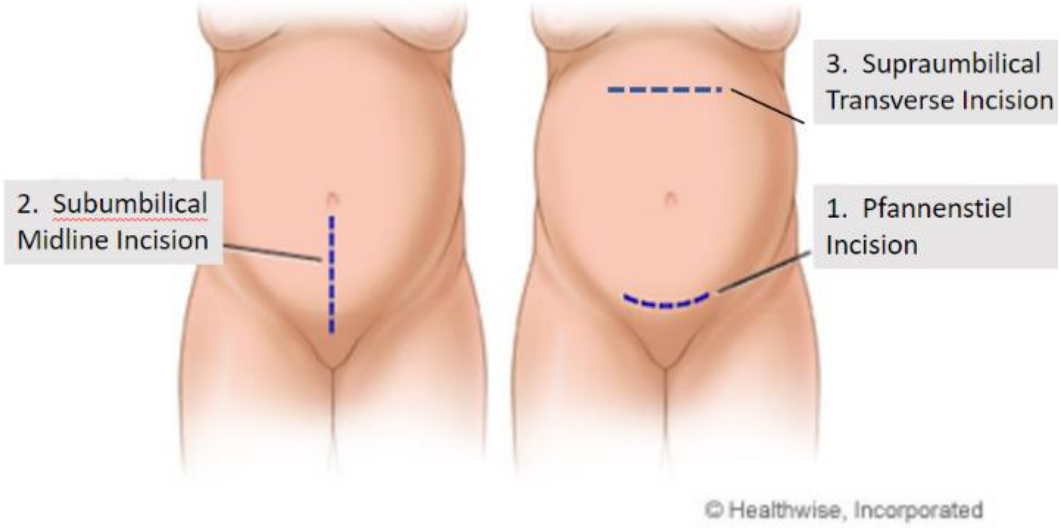

Figure 2:Three different incisions for caesarean section (https://oss-online.ca/knowledge-base/cs101-abd-entry/)

Vaginal delivery should be always the aim especially with previous bariatric surgery. (52) For successful vaginal delivery advise the obese pregnant women to limit their movements and prevent premature exertion. (51) Nevertheless, a full operating room must be on call and ready if a woman with a body weight exceeding 120kg is admitted. (50) Weight appropriate instruments and additional staffing may be required and ready at all times. (49–51) To ensure adequate monitoring during surgery, invasive arterial monitoring can be considered. Opioid sparing multimodal anesthesia should be used preferably local or regional. (51) There are three recommended incisions that can be seen in Figure two. High Pfannenstiel and low transverse incision guarantee a good access especially with additional elevation of the panniculus. (51) If fast access is needed the riskier access through a supra- or sub-umbilical incision may be done. (52) Subcutaneous suturing is necessary in women with a BMI >35 kg/m^2 or if subcutis is thicker than two centimeters to minimize infection risk. (49,51,52) Additional infection control is done by administering prophylactic antibiotics at cesarean section. (48–52) Depending on the guideline, different antibiotics adjusted according to weight are proposed. (48) For example, a single shot of 1g intravenous cephazolin for women with a body weight below 80kg, 2g if maternal body weight exceeds 80kg and from 120kg 3g of cephazolin are recommended. (50,51) Others suggest a single shot of cephalosporin 2g at least 60 minutes prior to surgery and 3g cephalosporin if maternal body weight exceeds 120kg. (52) As antacid prophylaxis and to reduce intraoperative aspiration risk H2-antagonsists are recommended every six to eight hours. (49,51) Postoperative prophylaxis should be adjusted according to maternal body weight and is composed of pharmacological and mechanical thromboprophylaxis. (48,50) After delivery, close surveillance and early management of maternal and newborn birth injuries is required. (51) Furthermore, active management of third stage to reduce postpartum hemorrhage. (48–51)

Shoulder dystocia is a serious complication and puts the mother at risk for postpartum hemorrhage and perineal lacerations. The most common complication associated with shoulder dystocia for the newborn is transient brachial plexus palsy. Evidence-based management, regular skills training and adequate treatment of fetus and mother is very important. (46) Intramuscular administration of Rh(D) immunoglobulin is not recommended due to decreased bioavailability in obese women, therefore if needed use intravenous administration. (50)

Postpartum care

During postpartum follow-up thorough examination of BMI and weight of mother and the offspring must be done. (52)Postpartum weight loss and healthy lifestyle adjustments should

be strongly encouraged and supported in women with antenatal obesity and especially those who plan another pregnancy. Interpregnancy weight loss reduces the risk for stillbirth, hypertension, macrosomia and raises the possibility of vaginal delivery also after previous cesarean section. (48) Most important for this is the education about the risk that obesity proposes on the mother and her offspring. (47,48) Lifestyle changes should be supported by the physician for example through a structured weight loss program or the referral to a dietician. (47–51) Weight should be monitored after birth for 12 to 18 months postpartum aiming antenatal body weight within six months. (47,51) Weight loss should be continued until BMI is within a healthy range. (48)

Especially obese women must be encouraged to breastfeed. (47,51,52) Support may be offered through lactation support services and devices, education about optimal positioning and support droning breastfeeding using pillows, props, or pumps. Weight stigmas and options that enable breastfeeding in social environments have to be discussed with the patient. (51) Support throughout all prenatal and postpartum period must be guaranteed hence obese women tend to stop breastfeeding earlier due to social stigmas considering their weight. (48–50) Some women may be worried about the quality of their milk, assuring that the quality of their milk does not change due to their obesity is important. (47)

If comorbidities occurred prior to or during pregnancy or delivery, reassessment must be done during the postnatal follow up appointments.(48) Gestational diabetes should include an annual screening for diabetes mellitus as well as assessment of cardiovascular risk factors. (49) Early mobilization proposes the most effective venous thromboprophylaxis. (49,51) In case of high risk for venous thromboembolism, development reassessment must be done during the follow-up appointments and a thromboprophylaxis must be given using low-weight heparin and compression stockings. (49,51) Surveillance of pulmonary function by a health care provider through temperature, heart rate and SpO2 monitoring is necessary to exclude a pulmonary embolism. (51) Screen for postpartum metal health disorder should be conducted. (48) Postnatal contraception should be adjusted to obesity. Therefore IUD is recommended over oral or transdermal contraception. (48–50,52)

Conclusion

The pathophysiological changes that occur in obese pregnant women propose a great harm to both mother and offspring. Most common pregnancy related complications include cardiovascular and hypertensive disorders. For example, preeclampsia is closely related to maternal obesity and prophylaxis for woman at risk is necessary.

Recent studies show a different hemodynamic profile, altered cardiac geometry and impaired diastolic indices in obese pregnant women that may be related to gestational hypertension and increased maternal morbidity. Gestational diabetes is more common due to higher insulin resistance. Postpartum depression, guilt and anxiety may interfere with adequate management of obesity. Some recent studies suggest hypothyroidism to be related with postpartum depression but this requires further research. Obese women are more likely to undergo cesarean section due to macrosomia, failed labor induction and fetal distress. Fetal distress and acidosis are most common indication for the admission to the neonatal intensive care unit. However, Babies born to obese women are more likely to be either large or small for gestational age. Early intervention by medical practitioners is required to identify babies that have a higher risk of comorbidities associated with childhood obesity. Additionally, stillbirth and miscarriage are more common among obese pregnancies. Clear international guidelines are needed for better management of obesity before, during and after pregnancy. This includes personalized management of comorbidities and adverse maternal and fetal pregnancy outcomes.

The management of obesity during pregnancy begins with the prevention of obesity and an early education about healthy lifestyle, nutrition, physical activity, and the benefits of a normal body weight index. Prenatal visits should include the assessment of body weight and height, calculation of the BMI and measurement of waist circumference. In case of overweight and obesity, weight loss must be emphasized and a consultation with a dietician has to be offered. Consider bariatric surgery in severe obesity prior to pregnancy. Post-operational micronutrient supplementation and close surveillance must be ensured. Contraception during the time of weight loss with a two-to-three-month period of weight stabilization is recommended. Furthermore, all prenatal comorbidities including mental health issues, iron, and vitamin B12 deficiencies need to be managed. At least one month prior to conception all obese women should receive supplementation with 5mg folic acid and vitamin D 200-600 IU/L.

However, education about short- and long-term risks of obesity on fertility, pregnancy, and offspring even after conception is recommended.

Maternal weight should be assessed at the beginning and towards the end of pregnancy. An overall weight gain of five to nine kilogramm is recommended for obese women. A consultation with a dietician can be helpful. High dose folic acid should be continued throughout the first trimester, all other supplementations must be sustained through all three trimesters. Prenatal screening should cover maternal comorbidities. Gestational diabetes must

be screened twice in obese women using the oral glucose tolerance test. The assessment of cardiovascular diseases should include blood pressure measurement and in case of hypertension an EKG. Gestational hypertension is a risk factor for preeclampsia; thus, obese women classify as high risk and should receive 150mg/d aspirin as prophylaxis. Antepartum and postpartum hemorrhage and anemia may require supplementation. Patients with a high risk for thrombosis require pharmacological and mechanical prophylaxis. Women with previous bariatric surgery should be under close surveillance for nutritional deficiencies and dumping syndrome. Adequate supplementation is most important in this case. If fetal assessment is difficult using transabdominal ultrasound, transvaginal ultrasound and reassessment between 28th and 32nd week needs to be considered. Serial ultrasound every two to three weeks from 28th gestational week observing fetal biometry and ensuring early intervention in abnormal fetal growth or intaurine movement.

Macrosomia is the most common indication for early labor induction. Otherwise, induction from 41st week is suggested. Delivery should be done in a prenatal center with adequate delivery and operating rooms. Early placement of continuous fetal intrauterine monitoring, venous and epidural/spinal access is necessary. Anesthesiologist and surgical team must be informed on admission and always be prepared for emergency cesarean section. In case of cesarean section, subcutaneous suturing to minimize risk of infection, if subcutis is thicker than two centimeters. Prophylactic antibiotics, H2 antagonists and venous thromboembolism prophylaxis administered in a timely manner is suggested to decrease risk for further complications. However, vaginal delivery should always be the aim along with active management of third stage and birth injuries to minimize postpartum hemorrhage.

Postpartum care should include monitoring of weight and follow up of comorbidities. Annual screening for diabetes mellitus after gestational diabetes, cardiovascular disease and endocrine disorders is recommended. Breast feeding must be supported by their health care provider or through lactations services and devices. Postpartum and especially interpregnancy weight loss through lifestyle changes should be encouraged and monitored. Postpartum contraception must be discussed.

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