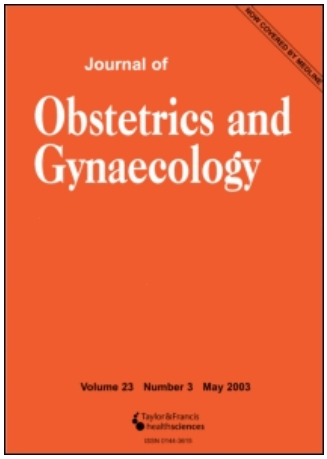

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Obesity and pregnancy

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Obesity and pregnancy

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Summary
Obesity is reaching pandemic proportions worldwide. It is increasingly being recognised as a risk factor during pregnancy. Women should ideally be counselled preconceptionally about the increased risks and encouraged to lose weight actively, some may be candidates for bariatric surgery. Maternal risks include gestational diabetes, hypertension and pre-eclampsia, increased incidence of operative delivery, postpartum haemorrhage, anaesthetic risks as well as infective and thrombo-embolic complications while fetal risks include miscarriage, neural-tube defects, macrosomia and stillbirth. Obstetric units should institute appropriate guidelines for the management of pregnancy in this 'high-risk' group of women.

Keywords
Obesity, pregnancy, morbidity, complications, mortality

Introduction

The prevalence of obesity is increasing worldwide and has been recognised by the World Health Organization (WHO 2000) as a pandemic nutritional disorder. It was initially a problem in the middle-aged and older population in the UK. However, over the last few years there has been an alarming increase in the rate of obesity in children and adolescents. Now 24% of women and 22% of men in the UK are obese (Vlad 2003). In the USA, 33% of women are obese (Ogden et al. 2006).

Consequently, there is a greater incidence of obesity in women of childbearing age. A Department of Health (DoH) survey in England (DoH 2002) showed that 32% of women aged 35–64 years of age are overweight (BMI 25–30 kg/m^2) and 21% are obese (BMI >30 kg/m^2) (DoH 2002).

The prevalence of obesity in pregnancy ranges from 8.1% to 11.8% depending on the cohort studied in different countries (Callaway et al. 2006; Usha et al. 2005). A recent study showed that 1 in 5 women booking for antenatal care in 2002/2004 were obese (Kanagalingam et al. 2005). A survey performed in the antenatal clinic in Sheffield (Fraser 2006) revealed that 17.5% of unselected women attending the antenatal booking clinic were obese. A longitudinal survey performed recently in Scotland showed a doubling of the number of antenatal women with a BMI over 30 between surveys performed in 1990 and 2002/2004 (9.4% vs 18.9%) (Kanagalingam et al. 2005).

Obesity has a major impact on reproductive performance – in terms of infertility and miscarriage as well as obstetric complications. Obesity is increasingly being recognised as a risk factor in pregnancy for a range of risks for mother and baby even after adjusting for confounding factors such as age and parity. Obstetric units should have local protocols to identify and minimise risks.

In addition, there is a considerable impact on service delivery such as associated cost of complications and provision of specialist equipment such as beds, hoists and chairs.

In the non-pregnant population, obesity is measured by calculating the body mass index (BMI) using the formula:

$$\text{BMI (Quetlet Index)} = \text{weight (kg)}/[\text{height (m)}]^2$$

The World Heath Organization (WHO) defines normal weight, overweight, obese and grossly obese according to BMI (Table I).

Preconception

It is widely known that women who are underweight have an increased risk of anovulatory infertility (RR 1.25; 95% confidence interval (CI) 1.2–1.6). There is now growing evidence that obese women have an even greater risk of anovulatory infertility [RR 2.5 (95% CI 2.0–3.7)] (Rich-Edwards 1994). This is often associated with oligo-amenorrhoea and polycystic ovarian syndrome although 80% of obese women had ovaries with normal morphology on ultrasound in a survey by Rich-Edwards (1994). Weight loss can correct the menstrual irregularities and also lead to resumption of ovulation.

As discussed above, pregnancy is still common in obese women whether spontaneous or with assisted conception. There are several large population-based epidemiological studies showing an association between obesity and adverse pregnancy outcome (Cedergren et al. 2004; Cnattingius et al. 1998; Ramussen and Kjolhede 2004; Weiss et al. 2004), and more recently, good data suggesting causality rather than casuality due to common risk factors (Villamor and Cnattingius 2006). In view of these increased risks of

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Table I. WHO classification of body weight using the body mass index (BMI) (WHO 2000)

BMI	Classification
<18.5	Underweight
18.5 – 24.9	Normal weight
25 – 29.9	Overweight
30 – 39.9	Obese
≥ 40	Morbidly obese

pregnancy complications, ideally, obese women should be assessed pre-conceptually, and adequately counselled. Weight loss should be actively encouraged via a weight reduction programme with dietary changes, exercise and behaviour modification. They should be made aware of the increased maternal (gestational diabetes, pregnancy induced hypertension and pre eclampsia, increased caesarean section rate as well as increased infective and thromboembolic complications) and fetal risks (miscarriage, neural tube defects, macrosomia and stillbirth), which may be a motivating factor in weight control.

This counselling, however, should be given in a non-judgemental way, as many of these women already have low self-esteem. They need support from the medical community to achieve sustainable weight loss, which may be rendered difficult by an underlying genetic tendency to obesity apart from environmental excess.

Optimisation of weight prior to conception is the goal, as weight loss is not recommended during pregnancy because of concerns regarding fetal growth. However, strong encouragement must be given to women to minimise weight gain in pregnancy and to strive to return to their pre-pregnancy weight as soon as possible afterwards. Recent data suggest that those women who gain >16 kg during pregnancy are most likely to remain overweight 1 and 15 years later (Linne and Neovius 2006), which has important implications both for future pregnancy and their future wellbeing. Women who gain even a modest amount of weight between pregnancies are at increased risk of adverse maternal and neonatal outcomes in the subsequent pregnancy, e.g. an increase by ≥ 3 BMI units between pregnancies significantly increases the risk of pre-eclampsia (odds ratio (OR) 1.78, 95% CI 1.52 – 2.08), gestational hypertension (OR 1.76, 95% CI 1.39 – 2.23), gestational diabetes (OR 2.09, 95% CI 1.68 – 2.61), stillbirth (OR 1.63, 95% CI 1.20 – 2.21), large for gestational age infant (OR 1.87 95% CI 1.72 – 2.04) (Villamor and Cnattingius 2006).

The number of women undergoing surgery to combat morbid obesity (Bariatric surgery) is increasing. Bariatric surgical procedures can be classified into two types:

1. Malabsorptive procedures: such as jejunoileal bypass and biliopancreatic diversion. These induce gastrointestinal malabsorption.
2. Restrictive procedures: which reduce the ability to eat large quantities of food such as gastric banding and vertical banded gastroplasty.

Both procedures can lead to deficiencies of iron, calcium, folic acid and vitamin B12.

Although early work suggested increased complications including gastrointestinal bleeding, anaemia, intrauterine growth restriction and neural tube defects, more recent evidence suggests that pregnancies in obese women who have undergone bariatric surgery are less likely to be complicated by gestational diabetes, hypertension, macrosomia and caesarean delivery as compared with those obese women who have not had surgery (ACOG 2005). The ACOG Committee Opinion on Obesity in Pregnancy (ACOG 2005) therefore recommends that women who have undergone bariatric surgery should be counselled preconceptionally regarding the following issues:

- They should be advised to avoid becoming pregnant during the rapid weight loss phase, i.e. 12 – 18 months after surgery.
- Women with adjustable gastric banding should be informed that weight loss following surgery may allow resumption of ovulation and so effective contraception should be used to prevent conception until their target weight has been achieved.
- Women with a gastric band will need careful monitoring in pregnancy by their surgeon. Loosening of the band may become necessary to allow more food to be eaten during pregnancy and therefore prevent continuing weight loss, which is not recommended after conception. Tightening of the band after delivery may be required in order to allow continuation of weight loss.
- These women will need evaluation during pregnancy for nutritional deficiencies with supplementation where indicated.

Although limited experience with management of morbidly obese women who became pregnant soon after receiving an adjustable gastric band has not revealed any greater risk of complications (Martin et al. 2000), further research is needed in this area. It would seem logical that pregnancy after the woman's weight loss has stabilised and she has achieved her target weight following bariatric surgery, would be associated with fewer complications as compared with pregnancy soon after bariatric surgery during the period of rapid weight loss. We believe, as others do, that women should be advised to delay pregnancy until weight loss has stabilised.

Ante-partum

At the booking visit, BMI should be calculated for all pregnant women, ideally using the pre-pregnancy weight. If the pre-pregnancy weight is unknown and BMI is being calculated in the first trimester, it is recommended that in order to get a more accurate estimate, 1 kg should be deducted before performing the calculation (Fraser 2006). If BMI were calculated solely in the third trimester, a significant number of women would be incorrectly defined to be morbidly obese.

Women with a BMI over 30 should be considered to be at 'higher risk'. Maternity units need to identify an appropriate cut off value above which referral to the obstetric team occurs antenatally and to develop protocols to identify and minimise the risks. The recent UK Confidential Enquiries into Maternal Deaths (2000 – 2002) recommends that obese women with a BMI of >35 should be booked for shared care with a consultant and delivered in a consultant obstetric unit (CEMACH 2004).

Women with morbid obesity (BMI >40) should ideally be referred antenatally for an anaesthetic review, particularly if they have co-existent medical conditions. The criteria for anaesthetic referral antenatally may, however, vary between units depending on the prevalence of obesity in the antenatal population and local protocols should be developed to suit the particular unit in discussion with the anaesthetists.

All obese pregnant women should be offered a referral to a dietician for dietary advice. They should be encouraged to follow an exercise programme. Weight loss via a calorie-controlled diet is not recommended in pregnancy, as there is no evidence of any benefit and there are concerns about the effect of excessive dietary restrictions on the fetal growth. Weight loss should be tackled before or in between pregnancies in order to minimise the risks associated with obesity in pregnancy (Villamor and Cnattingius 2006).

Currently, only limited guidelines are available regarding appropriate weight gain in pregnancy. Recommendations for antenatal weight gain have been based on the Institute of Medicine (IOM) guidelines 1990 (Table II).

A systematic review by the Californian School of Public Health of available observational data revealed that pregnancy weight gain within the IOMs recommended ranges is associated with the best outcome for mothers and infants (Abrams et al. 2000).

The relationship of gestational weight gain to pregnancy complications has not been extensively studied in obese women. The Institute of Medicine (IoM) report recommended a minimum weight gain of 7 kg (15 lb); however, no upper limit of weight gain was set on the basis of the data that were available (IoM 1990).

A retrospective study looking at pregnancy outcomes in obese and normal-weight women claimed that a weight gain of 7–11.5 kg (15–25 lb) for obese women and 11.5–16 kg (25–35 lb) for normal weight women was associated with optimal fetal growth (Edwards et al. 1996). In this study when compared with obese women who gained 7–11.5 kg, obese women who lost or gained no weight were at higher risk for small for gestational age (SGA) infants, while those who gained more than 16 kg were at twice the risk for delivery of large for gestational age (LGA) infants.

On the other hand, another retrospective cohort study concluded that weight gains of >16 kg were strongly associated with the birth of a LGA neonate ($p < 0.01$); however poor weight gain did not increase the risk of delivery of a SGA baby (Bianco et al. 1998). The question of whether morbidly obese women need to gain any weight at all during pregnancy remains largely unanswered and is an area where further research is needed.

Table II. Recommended total weight gain in pregnant women by pre-pregnancy BMI (kg/m^2) (IoM 1990)*

	Recommended total gain	
Pre-pregnancy BMI	(kg)	(lb)
<19.8	12.5–18	28–40
19.8–26.0	11.5–16	25–35
26.1–29.0	7.0–11.5	15–25
>29.0	7.0	15

*Adolescents and black women should strive for gains at the upper end of the recommended range. Short women <1.57 m should strive for gains at the lower end of the range.

Women should be informed of the potential complications of obesity in pregnancy. The complications can be divided into those directly related to the body mass index and those due to obesity *per se*.

Complications directly related to BMI

Ultrasound examination of the fetus can be more difficult in obese women particularly abdominally but is more likely to be requested due to the difficulties of identifying the fetal heart with sonicaid in the early second trimester and the inaccuracies of palpation in the third trimester. An early dating scan is often needed in obese pregnant women, as they are more likely to have had menstrual irregularities with longer cycles making the expected date of delivery unsure. A vaginal scan is usually more useful in these situations as abdominal scan can be technically very difficult.

Although, fetal biometry and basic anatomy scans can usually be optimally performed abdominally in most obese women, the technical difficulty and poor views obtained may impair a careful assessment of the fetal heart and intracranial anatomy thus making the diagnosis of fetal structural abnormalities more difficult. Wolfe et al. (1990) found no significant impairment of ultrasound visualisation until a body mass index above the 90th centile when visualisation fell by an average of 14.5%, being most marked for the fetal heart, umbilical cord and spine. No improvement was seen with advancing gestation or increasing duration of examination. More recently, Hendler et al. (2005) found suboptimal ultrasonographic visualisation (SUV) of the fetal heart in obese women with increasing rate of SUV with increasing BMI (1.5% for non-obese, 12% for BMI 30–34.9, 17% for BMI 35–39.9 and 20% for BMI ≥ 40; $p < 0.0001$) even on repeat cardiac examination.

Technically, it is more challenging to perform invasive diagnostic procedures such as chorionic villus sampling and amniocentesis and the risk of miscarriage due to these procedures is increased three-fold in the obese (Johnson et al. 1999).

Later in pregnancy, abdominal palpation to determine size, lie and presentation of the fetus is more difficult. Assessment of the fetal growth by measurement of the symphyseal fundal height is much less accurate and hence early detection of reduced uterine size and intrauterine fetal growth restriction may be compromised. Many recommend monitoring the fetal growth by ultrasound in morbidly obese women, but this also has significant restrictions (see above) and overinvestigation has the potential to increase operative intervention in this group at risk of surgical morbidity.

Complications due to obesity: Maternal

Diabetes. Obese women are more likely to have pre-existing diabetes and are also at increased risk of developing gestational diabetes (GDM). Around 17% of obese women develop GDM during pregnancy as compared with approximately 1–3% of women in general (Linne et al. 2002).

In a prospective multicentre study of over 16,000 patients (Weiss et al. 2004), obesity and morbid obesity had a statistically significant association with gestational diabetes (OR 2.6 and 4.0).

Kumari (2001) found an incidence of gestational diabetes of 24.5% in morbidly obese pregnant women as compared with 2.2% in the non-obese.

All obese women should be screened for undiagnosed Type 2 diabetes at booking and for gestational diabetes with a 50-g glucose challenge test early in the third trimester. In the morbidly obese women, consideration should be given to repeat testing at 34 weeks, despite a normal glucose screen earlier especially if accelerated fetal growth is identified.

Linne et al. (2002) followed up 28 women with GDM and a control group of 52 women for 15 years and found that women with GDM who developed type 2 diabetes gained significantly more weight since the birth of their first baby when compared with women without GDM and to those with GDM who did not develop type 2 diabetes. Hence to prevent the development of type 2 diabetes with its associated morbidity and mortality, it is recommended that active strategies for weight control and dietary management should be pursued in women with GDM postnatally.

Gestational hypertension and pre-eclampsia. Blood pressure (BP) measurements must be taken using sufficiently large cuffs as overestimation of BP by approximately 10 mmHg occurs if normal sized cuffs are used in obese women. To determine the cuff size needed, it is necessary to measure the circumference of the middle of the upper part of the arm (mid-arm circumference). The most common rule of thumb is that if the mid-arm circumference is >13 inches (33 cm), a larger cuff size is needed. Wrist devices for measuring BP overcome this problem, but as yet, they are not as accurate in pregnancy as upper arm devices (Wilton et al. 2006).

Obesity is an important risk factor for gestational hypertension (Andreasen et al. 2004). In the same study as quoted above (Weiss et al. 2004), the incidence of gestational hypertension (OR 2.5 and 3.2) and pre-eclampsia (OR 1.6 and 3.3) was increased in obese and morbidly obese pregnant women. In the study by Kumari (2001), the incidence of hypertensive disorders of pregnancy was 28.8% in morbidly obese vs 2.9% in the non-obese.

A systematic review by O'Brien et al. (2003) showed a consistently strong positive association between maternal pre-pregnancy BMI and the risk of pre-eclampsia, the risk of which doubled with each $5-7$ kg/m^2 increase in pre-pregnancy BMI. Overall, the literature shows that obese women have a $14-25$% incidence of pre-eclampsia (Castro and Avina 2002). However, there has been no specific work on whether prophylactic low dose aspirin or increased surveillance with uterine artery Dopplers are useful strategies in these women and this is an important area of further research (Coomarasamy et al. 2001).

Thromboembolism. Obesity is the most common risk factor for thromboembolism (Andreasen et al. 2004). Thromboembolism in pregnancy remains the leading cause of maternal death in the UK (CEMACH 2004). If hospitalisation is required for any reason, correctly fitting thromboembolic deterrent (TED) stockings and thromboprophylaxis with low molecular weight heparin (LMWH) (which may need to be at a higher and/or a twice daily dose) should be considered.

Respiratory complications. Obesity has been shown to have a causal relationship with asthma and sleep apnoea. In early pregnancy, obese women have increased rates of sleep apnoea, snoring and oxygen desaturation as compared with non-obese pregnant women (Sahota et al. 2003). Sleep apnoea can lead to pulmonary hypertension, right heart failure, drug-resistant hypertension, stroke and arrhythmias as well as increasing the risks of accidents due to daytime somnolence. The standard treatment for obstructive sleep apnoea (OSA) is nasal CPAP and there have been reports of its use in pregnant women with good outcome. A small case series has found nasal CPAP to be useful in reducing nocturnal blood pressure increments in women with pre-eclampsia when used to treat sleep related partial upper airway problems in women (Edwards et al. 2000). However, more research evidence is needed in this area before its clinical significance is established.

Maternal mortality. Obesity is associated with an increased incidence of maternal mortality from a number of different causes. In the most recent Confidential Enquiries into Maternal Deaths, 78 (35%) women who died from either a direct or indirect cause had a BMI over 30 (CEMACH 2004). Obese women of every age died from a variety of causes because either their physical size precluded optimal care or their obesity had direct clinical implications for their health.

Complications due to obesity: Fetal

Miscarriage. Obese women are at increased risk of first trimester miscarriages. At least three cohort studies suggest obesity to be an independent risk factor for spontaneous miscarriage in women who undergo assisted conception (Bellver et al. 2003, Fedorcsak et al. 2000, Wand et al. 2002). There are also data linking obesity with spontaneous miscarriage in women after natural conception (Lashen et al. 2004).

Congenital malformations. Evidence of the association between obesity and congenital malformations is conflicting. One case-control study found a significantly increased incidence of neural tube defects (NTD), defects of the central nervous system, cardiac malformations and gastrointestinal anomalies in infants born to mothers with a BMI >30 (Waller et al. 1994). Another study concluded that for every incremental unit increase (kg/m^2) in BMI, the risk of NTD increased by 7% (Watkins et al. 2003). The risk of neural tube defects is double among obese women compared with those of normal weight, after correcting for diabetes as a confounding factor (Shaw et al. 1996; Waller et al. 1994; Werler et al. 1996). However, other studies have found no association between maternal obesity and the risk of congenital malformations (Feldman et al. 1999; Moore et al. 2000).

The mechanism for this observed association of increased congenital malformations with maternal obesity is unclear. Possible explanations include increased serum insulin, triglyceride, uric acid and endogenous oestrogen as well as increased insulin resistance, chronic hypoxia and hypercapnia. The risk of NTD is also said to increase with maternal weight independent of folic acid intake as found in a case-control surveillance programme of birth defects where the authors concluded that a daily intake of folic acid 400 μg was protective against NTD in infants of women with a body weight <70 kg but not in infants of women weighing >70 kg (Werler et al. 1996).

Another possible explanation suggested for the association of congenital malformations with maternal obesity is a failure of detection because of the difficulty in sonographic assessment in these women.

Pre-term birth. Most studies report a lower incidence of spontaneous pre-term birth in obese than non-obese women. In one recent study from the USA, the OR was 0.57 (95% CI 0.39–0.83). Kumari (2001) also noted a significantly lower rate of prematurity in the obese (0.5%) as compared with non-obese women (5.3%). A possible explanation for this relates to leptin, which inhibits the onset of spontaneous uterine activity, and is found at higher levels in obese than in non-obese women (Moynihan 2006). This may also explain why postmaturity is more common in obese than non-obese women.

Iatrogenic prematurity may be increased due to pre-eclampsia, gestational diabetes, growth restriction, etc., which may explain why the neonatal death rate associated with pre-term birth in obese women was found to be higher in one UK study (Lucas et al. 1988).

Macrosomia. Fetal macrosomia has been defined in different ways in different studies – birth weight >4,000 g; birth weight >4,500 g or birth weight >90% for gestational age after correcting for neonatal sex and ethnicity. Several studies have shown an association between fetal macrosomia and maternal obesity and excessive weight gain in pregnancy (Cedergren 2004; Sebire et al. 2001; Weiss et al. 2004). Weiss et al. in their study found a significantly higher incidence of macrosomia in the obese and morbidly obese women: OR 1.7 and 1.9 for birth weight >4,000 g and OR 2.0 and 2.4 for birth weight >4,500 g, respectively. In the study by Kumari (2001), the incidence of macrosomia in the morbidly obese (32.6%) was significantly greater than in the non-obese (9.3%), $p < 0.001$.

Antepartum stillbirth. Studies have demonstrated an increased incidence of stillbirth in obese women. A large Swedish cohort study (Cnattingius et al. 1998) reported a greater risk of antepartum stillbirth among obese pregnant women as compared with those with a BMI <20. In a prospective population based cohort study ($n = 3{,}480$), there was a three-fold increased risk of antepartum stillbirth in morbidly obese women when compared with those with a normal BMI (Cedergren 2004).

Intra-partum

All the common complications of labour and delivery appear to be more frequent in the obese.

There is evidence that obese women have a tendency to post-maturity, thereby increasing the rate of induction of labour. In a large survey from London (Sebire et al. 2001), the OR for induction of labour was 1.7(95% CI 1.6–1.8) in women with a BMI >30. They also have a higher rate of failed induction (7.9 vs 10.3 vs 14.6% with increasing BMI; $p < 0.001$) (Kabiru and Raynor 2004).

During labour, there may be technical difficulty with external cardiotocographic monitoring due to the increased layer of adipose tissue between the transducer and the fetus. Once the woman is in active labour and membranes have been ruptured, this problem may be obviated by the use of fetal scalp electrode, although these are sometimes not long enough.

There is a higher incidence of operative vaginal delivery in obese women (8.4% vs 11.4% and 17.3% with increasing BMI; $p < 0.001$) (Kabiru and Raynor 2004). When obese women require an instrumental delivery, it can be difficult to make a thorough assessment as both abdominal palpation of the head and vaginal assessment of fetal position are challenging. Cervico-vaginal tears and lacerations can be extremely difficult to identify and repair due to limited access, increased vaginal length and vaginal adipose tissue. An experienced obstetrician should be available when performing assisted vaginal delivery in these women.

There is an increased incidence of shoulder dystocia secondary to both fetal macrosomia and soft tissue dystocia due to a relative excess of fat in the pelvis (1% vs 1.8% and 1.9% with increasing BMI; $p < 0.021$) (Kabiru and Raynor 2004). The routine manoeuvres for shoulder dystocia, such as McRoberts' position and suprapubic pressure, may be ineffective in obese women because of soft tissue dystocia and early resort to the internal rotatory manoeuvres or extraction of the posterior arm should be undertaken (Poggi et al. 2003). There is an increased incidence of third/fourth degree perineal tears (26.3% vs 27.5% and 30.8% with increasing BMI; $p < 0.001$) (Kabiru and Raynor 2004).

Caesarean section

Several studies have shown an increased incidence of primary caesarean section in obese women when compared with non-obese (Kumari 2001; Sebire et al. 2001; Weiss et al. 2004). In the London Survey (Sebire et al. 2001) the OR of an emergency caesarean section in obese women was 1.8 (95% CI 1.7–1.9). In a recent study, the rate of caesarean section for failure to progress or for cephalo-pelvic disproportion was six-fold higher in women with a BMI >30 than in women with a BMI <20 (Kaiser and Kirby 2001). In a separate study, a BMI >30 was an independent risk factor for caesarean section at full dilatation [OR 2.3 (95% CI 1.1–4.5)] (Fraser 2006).

High leptin levels found in obese women in pregnancy (10-fold increase) have been suggested to be responsible for the increased caesarean section rate in these women. Leptin has been shown to exert an inhibitory effect on both spontaneous and oxytocin-induced contractions in human myometrium *in vitro* (Moynihan et al. 2006). Another recent study found that myometrium from obese women contracted with less force and frequency and had less [Ca^{2+}] flux *in vitro* than that from normal-weight women (Zhang et al. 2007).

In morbidly obese women, caesarean section can be a technically challenging procedure due to restriction of surgical access. The panniculus can make exposure very limited and occasionally a midline incision may be indicated. Limited exposure can make suturing difficult; more so if there has been an angle extension. Exteriorisation of the uterus to facilitate suturing may be very difficult in these women. This helps to explain the longer operating times noted in obese women compared with controls.

In morbidly obese women, careful consideration should be given to the type of skin incision to be used and each case should be assessed individually with careful pre-operative planning. Most often, a Pfannenstiel incision is used, the advantages of which include a more secure closure, less fat dissection and less postoperative pain,

which facilitates earlier mobilisation and deep breathing thus reducing the incidence of atelectasis and hypoxaemia. Its disadvantages are difficult surgical exposure due to the large pannus, potential for maternal cardiorespiratory compromise due to retraction of the large pannus to gain better access and increased rate of wound infection due to the warm and moist area under the pannus. In contrast, the vertical midline incision allows better visualisation of the operative field, less physical exertion by the operator and assistants, decreased operative time and reduced blood loss. However, it is associated with increased postoperative pain limiting deep breathing exercises with consequent increased risk of postoperative atelectasis as well as increased rate of incisional hernia.

Some obstetricians have advocated the use of midline supra-umbilical incisions or transverse incisions above the pannus. In instances where the panniculus pulls the abdominal wall downwards, some suggest a transverse incision at the level of the umbilicus, which is said to provide excellent access to the uterus in these cases (Alexander and Liston 2006).

Aseptic technique is particularly important in these women as they are at increased risk of wound infections. Alexander and Liston (2006) suggest preparing the skin with a povidone-iodine solution (or similar) 30–40 min preoperatively and then to re-cleanse the skin in the usual manner just prior to commencing the caesarean, taking special care under the panniculus and in the groin area. This is said to be beneficial in reducing skin colonisation and subsequent wound infection.

Care should be taken to ensure an adequate length of the incision as poor access can be physically more taxing on the surgeon and assistant as well as increase the operative time.

Special instruments, such as retractors with deeper blades may be needed to facilitate surgery.

The importance of good haemostasis cannot be over-emphasised both at the time of incision and closure with liberal use of diathermy to minimise the risk of haematoma formation and intra-peritoneal bleeding (Kearns et al. 2001).

Extra care should be taken while closing the rectus sheath and some recommend using a delayed absorbable suture such as polydioxanone (PDS) or polyglyconate (Maxon) instead of polyglactin (Vicryl) as they invoke little tissue reaction and retain half their tensile strength at 4 weeks.

In case of vertical skin incisions, mass closure with either a permanent or a delayed absorbable monofilament suture such as PDS reduces the risk of wound dehiscence.

A Cochrane review showed that there is no evidence that routine use of a wound drain confers any benefit (Gates and Andersen 2005). A randomised study suggests that closure of subcutaneous fat in women in whom that layer is >2 cm reduces the rate of postoperative wound complications such as seroma and haematoma formation (Allaire et al. 2000).

For skin closure, particularly in morbidly obese women, an interrupted suture or staples are recommended so that if a small haematoma or a localised area of infection develops, a few sutures/staples can be removed to help its resolution (Alexander and Liston 2006).

Other technical problems may be encountered, such as the transfer of the woman to an operating table, especially if she has an effective epidural; extra personnel may be required for safe transfer. Special large operating tables may be needed for the morbidly obese women. These problems should be anticipated antenatally and appropriate arrangements made well in advance. In an emergency situation, it may become necessary to operate with the woman on a bed, which is suboptimal as it limits access and makes it more difficult for the anaesthetist and obstetricians.

Vaginal birth after caesarean section (VBAC)

Obesity is associated with a reduced likelihood of successful VBAC. The success rate for VBAC in the morbidly obese woman was found to be 13% in a study from Mississippi (Chauhan et al. 2001) In a Chicago study of 725 women, obesity was found to be an independent adverse risk factor for VBAC (Goodall et al. 2001).

Chauhan et al. (2001) also reported higher rates of endometritis and wound breakdown in those obese women who underwent a failed attempt at VBAC. Grobman et al. (2000) calculated that a 40% VBAC success rate would be needed to reduce costs and lower maternal morbidity. On this basis, Chauhan et al. (2001) suggest elective caesarean section rather that VBAC in morbidly obese women.

However, others have found higher rates of successful VBAC in obese women 68.2% as compared with 79.9% in the non-obese in a New York study (Juhasz et al. 2005) and $>65\%$ (Carroll et al. 2003).

The issue needs to be addressed in larger randomised trials. It is also important to remember not only the increased infectious morbidity shown in these studies among obese women who undergo a trial of labour but also that the potential management of uterine rupture in the morbidly obese women can be fraught with surgical difficulties and the resultant morbidity may be extreme.

Anaesthetic complications

From an anaesthetic perspective, morbidly obese women can be quite challenging to manage and so they should have an anaesthetic assessment antenatally. The UK Confidential Enquiries into Maternal Deaths 2002–2004 recommend an antenatal anaesthetic referral for women with a BMI >35 (CEMACH 2004). Obese women are also likely to have a higher incidence of concomitant medical problems which may be of relevance to the anaesthetist when planning obstetric analgesia/anaesthesia.

Obtaining venous access may be difficult. Siting of an epidural or spinal anaesthetic for analgesia can be more difficult due to the increased depth of tissue to the intervertebral space as well as difficulty in identification of spinal bony landmarks. The initial failure rate of epidural cannulation in the morbidly obese has been reported to be as high as 42% (Hood and Dewan 1993), hence the rate of general anaesthetic with its potential complications (more so in the obese) is higher. Dresner et al. (2006) found increasing incidence of epidural failure and epidural re-site rates with increasing BMI. The rate of general anaesthetic has been quoted to be as high as 62.5% in morbidly obese women undergoing caesarean section in a small and relatively early study (Hodgkinson and Husain 1980).

The incidence of difficult endotracheal intubation is 10 times higher in the obstetric population as compared with the general population; in morbidly obese pregnant women it has been quoted to be as high as 33% (D'Angelo and Dewan 2004). In difficult situations, awake fibreoptic intubation may be required.

Obstetricians should be aware of the increased time required to perform a regional or general anaesthetic in these women and the impact it may have on situations, such as suspected fetal compromise. Advance planning and good communication between obstetricians and anaesthetists is thus vital.

At caesarean section, a semi-recumbent rather than supine position may need to be adopted to maintain adequate breathing in morbidly obese women. Panniculus retraction can cause severe cardiovascular compromise and suspending the panniculus vertically has been suggested as a solution (Hodgkinson and Husain 1980).

Effective communication and good teamwork is absolutely essential between the anaesthetist and obstetrician for the safety of both mother and baby. Advanced planning of anaesthesia for both elective and emergency situations is recommended with involvement of the woman in decision-making based on the best available evidence.

Postpartum

Postpartum haemorrhage

There is evidence to suggest that obese parturients have a greater incidence of postpartum haemorrhage (PPH) (Usha et al. 2005). Although the increased incidence of caesarean section in this group of women is no doubt contributory, it is not the only influencing factor.

Sebire et al. (2001) noted a 44% increased risk of major PPH in women with a BMI >30, even after correcting for confounding factors such as caesarean section. The risk of PPH rises with increasing BMI and is about 30% more frequent for women with a moderate obesity and 70% more frequent for those with gross obesity compared with women of normal weight. The explanation suggested by these authors is more bleeding from the relatively larger implantation area of the placenta being associated with a large for gestational age fetus however the poor contractility of uterine myometrium shown *in vitro* in studies is likely to be responsible for the increased risk of PPH (Moynihan et al. 2006; Zhang et al. 2007).

Genital tract trauma significantly contributes to the increased risk of PPH, apart from uterine atony as obese women are at increased incidence of third/fourth degree perineal tears (26.3% vs 27.5% and 30.8% with increasing BMI; $p < 0.001$) (Kabiru and Raynor 2004), which may also be more difficult to repair due to limited access and increased vaginal length and adiposity.

Thromboembolism

Obese women are at increased risk of deep vein thrombosis and pulmonary embolism in the postpartum period particularly if they have had an operative delivery. Even after a vaginal delivery, they should be encouraged towards early mobilisation, good hydration and use of thromboembolic deterrent (TED) stockings. Consideration should be given to the use of low molecular weight heparin (LMWH) prophylaxis even after a vaginal delivery especially in women who are not very mobile or those with co-morbidities such as pre-eclampsia.

For those with an operative delivery, the standard prophylactic dose of 40 mg enoxaparin may be inadequate and some suggest that it is given as 40 mg twice a day. Consideration should also be given to an extended duration of prophylaxis particularly in the morbidly obese, and especially if mobility is restricted: a dose of 40 mg daily or twice daily for 2–6 weeks is recommended (Hamad and Choban 2005).

Infective morbidity

There is an increased incidence of postoperative atelectasis and pneumonitis – early mobilisation, chest physiotherapy and adequate pain control can reduce these. Nursing in a reclined position and supplemental oxygen are very helpful in reducing respiratory events.

There is increased incidence of postoperative wound infection – good surgical technique, meticulous haemostasis and closure of subcutaneous fat can reduce the incidence of postoperative wound complications. The incidence of postpartum endometritis is also increased in obese women particularly after operative delivery. The incidence of urinary tract infection is also increased, presumably because aseptic technique during catheterisation is difficult.

As the volume of distribution is increased in obese women (Cheymol 2000), it would seem reasonable to administer a larger dose of antibiotic for prophylaxis at the time of caesarean section to reduce the incidence of wound infection and endometritis. Some recommend antibiotic cover for 24 h after caesarean section. These recommendations are, however, not evidence based and this again is an area with potential for further research.

Lactation

Maternal obesity is associated with an increased risk of failure to initiate lactation and decreased duration of breast-feeding (Donath and Amir 2000; Li et al. 2002; Sebire et al. 2001), which is disappointing as the 1,000 kcal daily expenditure would help with postnatal weight control. Obesity is associated with a reduced prolactin response to suckling (Ramussen and Kjolhede 2004). The aetiology is likely to be multifactorial and the simple mechanical difficulties of proper infant positioning and latching-on may be the key factors which might be addressed with lactation assistance.

Prolonged hospital stay

Obese women have a significantly higher incidence of hospitalisation beyond 4 days compared with non-obese women. This has significant health resource implications (Nuthalapaty and Rouse 2004).

Education and risk management

Postnatally, these women should be advised on the long-term health risks of obesity in the form of hypertension, diabetes, dyslipidaemia and cardiovascular morbidity and encouraged to lose weight particularly prior to any future pregnancy. They may be candidates for drug treatment of obesity or bariatric surgery.

Contraception

Contraceptive advice is of paramount importance in these women. Obesity is a risk factor for thromboembolism and for cardiovascular disease, and its synergistic effect with the

combined oral contraceptive pill (COCP) should be considered prior to prescribing it to an obese woman. Other risk factors for both VTE and cardiovascular diseases must be taken into account before a final decision is made. The British National Formulary (BNF) has helpful guidance on this and recommends their use with caution if the BMI >30 kg/m^2, and to avoid them if the BMI is >39 kg/m^2 or the BMI is >30 kg/m^2 plus one or more other risk factors such as family history of VTE or arterial disease in first degree relative, long-term immobilisation, varicose veins, diabetes mellitus, hypertension, smoking, age over 35 years and migraine (BNF 2006).

There are several highly effective and simple progestogen-only contraceptive methods available for consideration, such as Mirena, Implanon, Depo-Provera and the progestogen-only pill (POP). Copper intrauterine device (IUD) can also be used preceded by screening for chlamydia.

Following discharge, it is important to communicate the outcome and findings to the general practitioner as well as plans for follow-up or treatment in the community (Alexander and Liston 2006).

Future research

Some of the areas for potential research in the context of obesity and pregnancy are:

- Pregnancy outcome before and after bariatric surgery
- Weight gain recommendations in pregnancy for morbidly obese women
- Feasibility of low dose aspirin prophylaxis and/or use of uterine artery Doppler studies for prediction of pre-eclampsia
- Outcome of VBAC in morbidly obese women
- Dosage regime for antibiotic prophylaxis at caesarean section in obese women.

There is new and exciting work linking maternal obesity and fetal programming, which adds extra weight to the numerous reasons to encourage women to avoid obesity. Hypertension, diabetes and the metabolic syndrome all seem to be more likely in individuals whose mothers were obese during their pregnancy (Armitage et al. 2005).

Recommendations

Obstetric units need to work out local strategies for obese women. These might include:

1. Increased surveillance for pre-eclampsia such as home testing of urine for protein and regular blood pressure recordings
2. Screening for gestational diabetes
3. Thrombo-prophylaxis
4. Anaesthetic referral
5. Dietary advice and weight control support.
6. Provision of mechanical aids such as hoists and a stronger/larger delivery bed and operating table for women whose weight precludes the use of standard equipment.

Conclusions

Maternal obesity needs to be recognised as a risk factor in pregnancy. With its rising incidence, midwives and obstetricians need to be aware of the maternal and fetal risks associated with obesity. The women should be made aware of these risks and given appropriate dietary and lifestyle advice. Potential complications should be anticipated in advance and management plans put in place in order to optimise maternal and fetal outcome.

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