Best Practice & Research Clinical Obstetrics & Gynaecology 92 (2024) 102425

Contents lists available at ScienceDirect

Best Practice & Research Clinical Obstetrics & Gynaecology

journal homepage: www.elsevier.com/locate/bpobgyn

Challenges in timing and mode of delivery in morbidly obese women

Nivedita R. Aedla[a,*], Tahir Mahmood[b], Badreldeen Ahmed[c,d,e], Justin C. Konje[c,d,f,g]

[a] *Simpsons Centre for Reproductive Medicine Royal Infirmary of Edinburgh, Edinburgh, UK*
[b] *Spire Murrayfield Hospital, Edinburgh, UK*
[c] *Fetal Maternal Centre, Doha, Qatar*
[d] *Weill Cornell Medicine Qatar. Qatar*
[e] *University of Qatar, Qatar*
[f] *Department of Health Sciences, University of Leicester, UK*
[g] *University of Ho, Ghana*

A R T I C L E I N F O

Keywords:
Obesity
Pregnancy
Stillbirth
Timing of birth
Prolonged pregnancy
Induction of labour
Caesarean section

A B S T R A C T

Globally obesity is increasing especially in the reproductive age group. Pregnant women with obesity have higher complication and intervention rates. They are also at increased risk of stillbirth and intrapartum complications. Although organisations like NICE, RCOG, ACOG and WHO have published guidelines and recommendations on care of pregnant women with obesity the evidence from which Grade A recommendations can be made on timing and how to deliver is limited. The current advice is therefore to have discussions with the woman on risks to help her make an informed decision about timing, place, and mode of delivery.

Obesity is an independent risk factor for pregnancy complications including diabetes, hypertension and macrosomia. In those with these complications, the timing of delivery is often influenced by the severity of the complication. As an independent factor, population based observational studies in obese women have shown an increase in the risk of stillbirth. This risk increases linearly with weight from overweight through to class II obesity, but then rises sharply in those with class III obesity by at least 10-fold beyond 42 weeks when compared to normal weight women. This risk of stillbirth is notably higher in obese women from 34 weeks onwards compared to normal weight women. One modifiable risk factor for stillbirth as shown from various cohorts of pregnant women is prolonged pregnancy. Research has linked obesity to prolonged pregnancy. Although the exact mechanism is yet unknown some have linked this to maternal dysregulation of the hypothalamic pituitary adrenal axis leading to hormonal imbalance delaying parturition. For these women the two dilemmas are when and how best to deliver.

In this review, we examine the evidence and make recommendations on the timing and mode of delivery in women with obesity. For class I obese women there are no differences in outcome with regards to timing and mode of delivery when compared to lean weight women. However, for class II and III obesity, planned induction or caesarean sections may be associated with a lower perinatal morbidity and mortality although this may be associated with an increased in maternal morbidity especially in class III obesity. Studies have shown that delivery by 39 weeks is associated with lower perinatal mortality compared to delivering after in these women. On balance

* Corresponding author.
E-mail address: nivedita.aedla@nhslothian.scot.nhs.uk (N.R. Aedla).

https://doi.org/10.1016/j.bpobgyn.2023.102425
Received 7 September 2023; Received in revised form 31 October 2023; Accepted 13 November 2023
Available online 22 November 2023
1521-6934/

the evidence would favour planned delivery (induction or caesarean section) before 40 weeks of gestation. In the morbidly obese, apart from the standard lower transverse skin incision for CS, there is evidence that a supraumbilical transverse incision may reduce morbidity but is less cosmetic. Irrespective of the option adopted, it is important to discuss the pros and cons of each.

1. Introduction

Obesity, defined as abnormal or excessive fat accumulation that presents a risk to health is currently one of the greatest social burdens caused by human behaviour. Rates of obesity have risen significantly over the last 2 decades to an extent that this is now considered an epidemic. The rise in levels has been throughout the world with most in middle income countries and to a lesser extent some low-income countries. In high-income countries the rise is not universal with the USA having the highest obesity rate [1]. The prevalence of obesity tripled between 1975 and 2016 when it was estimated that there were 1.9 billion over weight adults of which 650 million were obese (BMI $\geq$30 kg/m^2) (340 million adolescents and 39 million children), implying that 39 % (39 % of men and 40 % of women) of adults aged 18 or over were overweight, and 13 % were obese. Obesity has a significant negative impact on health with an estimated 2.8 million people dying each year as a result of being overweight or obese. If current trends continue unchecked, the World Obesity Federation (WOF), predicts that one billion people globally, including 1 in 5 women and 1 in 7 men, will be living with obesity by 2030 [2]. Obesity is twice more common among women than men with a significant number of this in the reproductive age group [3].

Obesity especially morbid obesity (define as BMI $\geq$40 kg/m^2) is associated with or is a cause of several morbidities in obstetrics and gynaecology [4]. In obstetrics the challenges of morbid obesity are myriad. These include monitoring of maternal health, imaging the fetus and monitoring fetal growth and delivery. Perinatal outcomes in obese women are much higher than in normal weight women. Morbid obesity is associated with higher induction of labour rates, longer duration of labour, more labour dystocia requiring syntocinon augmentation, higher rates of operative deliveries, postpartum haemorrhage and chorioamnionitis and infections and venous thromboembolism [5]. Emergency caesarean section rates are up to 50 % compared to 10 % in normal weight women [6]. Furthermore, following caesarean sections there is an increased risk of endometritis, wound infections, fascial dehiscence, and haematoma/seroma formation [7]. Stillbirth rates in obese women are significantly higher and more so in those who are morbidly obese [8]. Several factors have been advanced for the increased stillbirth and perinatal mortality rates in morbidly obese women. These include prolongation of pregnancy and problems monitoring. In this article, we review the evidence for when and how best to deliver morbidly obese women.

1.1. Duration of pregnancy

It has been suggested that maternal body mass index (BMI) and nutrition may be involved in the timing of the onset of labour, operating possibly through endocrine mechanisms [9]. Preterm delivery for example is more common in women who are underweight than in those of normal weight [10]. A study from Israel showed that restricting nutrition in women may indeed initiate labour [11]. If the converse is true, then it would be less likely for women who are obese to go into spontaneous labour at term and thus be at increased risk of having postdate pregnancies [12]. These women, who by virtue of their obesity are already at high risk, would be more likely to have induced labours for postdates with a potential further rise in surgical intervention, morbidity, and mortality.

A significant decrease in the rate of spontaneous labour from 41weeks of gestation has been observed in obese patients [13]. The increased rate of induction of labour in obese women at 41^{+6} weeks gestation reported from some studies could therefore reflect a higher proportion of the reduced rate of spontaneous labour. Several studies [12–16] have indeed reported a longer gestation in obesity, with delivery occurring more frequently between 41 and 42 weeks of gestation (presumably because of a reduced rate of spontaneous labour). Prolonged pregnancy is reported to affect about 30 % of obese patients compared to 22 % of patients with a normal BMI (OR: 2.2)[17] Prolonged pregnancy is therefore one of the most common complications in obese patients.

Denison et al. [12] showed that in pregnancies that extended beyond 260 days, a higher maternal BMI during the first trimester was associated with an increased risk of postdates pregnancy. They also found that the greater the increase in maternal BMI between first and third trimesters the longer the gestation and furthermore that maternal BMI in the first trimester influenced the risk of spontaneous onset of labour at term. The proportion of women with a BMI of 35 kg/m^{2}or more in this study in the first trimester who went into spontaneous onset of labour at term was approximately 50 % lower than in those with a normal BMI in the first trimester. Denison and colleagues [12] by using an accurate method of determining change in maternal BMI with gestation in their large database of 43,783 women showed that the greater the increase in maternal BMI during pregnancy, the longer the gestation. In two other studies change in maternal BMI was shown to affect the length of gestation [17,18]. The first one, a case–control study (n = 3191) showed that increased maternal gestational weight gain was associated with a higher risk of post-term delivery [17] and the second showed that excessive gestational weight gain was associated with prolonged pregnancy [18]. We can infer from these studies that if this relationship indeed proves causal, then it could be said that there would be the expectation of an increase in the prevalence of postdate pregnancies world-wide since the rate of maternal obesity is rising.

How could this relationship between weight and duration of pregnancy be explained? The precise factors that control length of gestation and onset of parturition are poorly understood. Having said that it is known that circulating levels of corticotrophin-releasing hormone, mainly synthesised by the placenta [19], and plasma cortisol at 22–24 weeks are significantly lower in women who deliver at term compared with those who deliver preterm [20]. Additionally, there is a less rapid rise in maternal corticotrophin-releasing hormone in women who deliver post-dates compared with those who deliver at term or preterm [21,22]. Although obesity is associated with activation of the hypothalamic–pituitary–adrenal axis, cortisol clearance is also increased, and plasma cortisol levels are often low or normal [23–25]. Furthermore there is a clear-cut inverse linear correlation between plasma cortisol levels and relative weight in nonpregnant women [26]. Taken together these observations would suggest that obese women are therefore likely to have lower circulating cortisol levels during pregnancy than those of normal weight women. A consequence of this could be reduced placental corticotrophin-releasing hormone production and ultimately an influence on the timing of delivery [27]. Alternatively, in obese women, higher concentrations of oestrogen in adipose tissue may result in a reduction in the levels of circulating oestrogen and an alteration in the oestrogen: progesterone ratio in maternal plasma, which increases prior to normal delivery [28]. No studies have investigated the effect of maternal obesity on uteroplacental biology, the hypothalamic-pituitary axis and changes in hormones (involved in parturition) during normal pregnancy. Despite all these observations we feel that while obesity is indeed a factor in prolonging pregnancy, the mechanisms by which obesity influences parturition trigger will be complex and multifactorial. There is thus the need for studies to confirm these interesting findings and to explore possible mechanisms.

1.2. Stillbirths

Globally, nearly 2 million stillbirths (SBs) were reported in 2019 which is likely to be an underestimation [29]. Causes of stillbirth are potentially modifiable; some of these include lifestyle and nutritional factors (which account for 10 % of SBs) and prolonged pregnancy (accounting for 14 % of SBs) [30]. Term stillbirth is considered as that occurring at $\geq$ 37 weeks. While many stillbirths are attributable to placental dysfunction and growth restriction, more studies are emerging identifying obesity as an independent risk factor. Maternal overweight and obesity (BMI >35 kg/m^2) has been identified as the highest-ranking modifiable risk factor after 22 weeks of gestation especially in high income countries [31]. The risk of stillbirth at term in all pregnancies (37^{+0}- 41^{+6}) is reported as 1.23 per 1000 total births [32]. Maternal obesity more than doubles the risk of stillbirth and neonatal death [33,34]. In a population-based study in Sweden of 64,632 overweight or obese women, from which a total of 61,800 records were analysed (4855 were obese with BMI ranging from 30 to 34 kg/m^2 and 16,900 were class III obesity of BMI$\geq$ 35 kg/m^2) it was concluded that women who were obese or severely obese had a higher risk of almost all the pregnancy outcomes including stillbirths (RR 2.16; 95 % CI 1.31–3.55) [34].

A meta-analysis of the association of stillbirth with maternal obesity concluded that women who are overweight and obese were at an increased risk compared with normal-weight women. The unadjusted odds ratios were calculated as 1.47 (95 % CI, 1.08–1.94) for overweight women and 2.07 (95 % CI, 1.59–2.74) for obese women [35]. The largest retrospective cohort study from Canada published in 2021, that reviewed around 12.8 million births concluded that compared with women of normal BMI the risk of stillbirth at term in women with raised BMI was higher. This risk was shown to rise in a dose-response relationship with class 1 obese women at 39 weeks, class II obese women from 38 weeks and class III obese women from 37 weeks [36]. Similarly another retrospective cohort study in US reviewing 2.4 million births concluded that delivery by 38 weeks in morbidly obese women reduced perinatal mortality. The stillbirth rate in the obese group increased from 1.8 per 10,000 births at 34 weeks to 10.5 per 10,000 births at 42 weeks. Perinatal mortality risk favoured delivery at 39 weeks (RR: 1.17; 99 % CI: 1.01–1.36). In the morbidly obese group stillbirth risk increased from 8.8 per 10,000 births at 34 weeks to 83.7 per 10,000 births at 42 weeks favouring reduced perinatal mortality for delivery from 38 weeks (RR: 1.53; 99 % CI: 1.16–2.02). In women with morbid obesity, 428 (99 % CI: 279–916) need to be delivered at 39 weeks to prevent one stillbirth. At 41 weeks, 147 (99 % CI: 87–447) women need to be delivered to prevent one stillbirth [37].

Another retrospective cohort study in US published in 2014, examined the association between pre pregnancy BMI and risk of stillbirth in more than 2.8 million births (excluding anomalies) and concluded that there was an increased risk of stillbirth with increasing BMI. Obesity was associated with nearly 25 % of stillbirths that occurred between 37 and 42 weeks' gestation (after excluding anomalies and other confounding factors such as maternal age). Extreme maternal obesity was a significant risk factor for stillbirth. Women with a BMI of 50 kg/m^2 and over were 5.7 times more likely to have stillbirth compared with normal weight women at 39 weeks' gestation. As the gestational weeks progressed the stillbirth rate rose and was 13.6 times higher at 41 weeks. Once again, a dose-response relationship between obesity and stillbirth was observed consistent with other studies (Table 1). There was a linear increase in stillbirth in overweight women through to women with class II obesity. However, women with class III obesity had a higher nonlinear increased in stillbirth between 30 and 42 weeks' gestation [38].

Table 1
Obesity & Stillbirth risk (Akelsson 2023 [34], Chu 2007 [35], Eberle 2022 [36], Yao 2019 [37], Yao 2014 [38]).

Study (year & country)	Study design	Dates of data collection	Inclusion criteria	Sample size (N)	Overweight Stillbirth risk	Obese Stillbirth risk	p-value	Strengths and Limitations	Ref. no
Sweden 2023	Population-based cohort study	January 2016–June 2018	Overweight or obese women (over 28 weeks)	61,800	RR 2.06 (95 % CI 1.01–4.21)	RR 2.16 (95 % CI 1.31–3.55)	0.006	Strengths: -low missing values Limitations: -Regional differences in prevalence of obesity -Cause of stillbirth not known -Potential confounders not adjusted	Akelsson 2023 [34]
2007	Meta-analysis	January 1980–September 2005	Overweight and obese women	9 studies included	Unadjusted OR 1.47 (95 % CI 1.08–1.94)	Unadjusted OR 2.07 (95 % CI 1.59–2.74)		Strengths: -estimates not affected by study characteristics Limitations: -mechanism for increased risk unclear	Chu 2007 [35]
USA 2022	Retrospective population-based cohort study	2014–2017	Singleton term births with recorded pre-pregnancy BMI	12,742,980 births		Class I at 39 weeks- OR 1.15 (95 % CI 1.00–1.31) Class II at 38 weeks- OR 1.21 (95 % CI 1.04–1.41) Class III at 37 weeks- OR 1.30 (95 % CI 1.11–1.52)		Strengths: -missing data is small -comorbidities not adjusted -WHO BMI categories Limitations: -congenital anomalies not excluded -coding errors -gestational age may be when fetus delivered	Eberle 2022 [36]
Texas 2017	Retrospective cohort study	2006–2011	Singleton non-anomalous births (over 34 weeks)	2,149,771		Class I at 34 weeks- 1.8 per 10,000 Class 1 at 41 weeks- 10.5 per 10,000 Class III at 34w- 8.8 per 10,000 Class III at 41 weeks- 83.7 per 10,000		Strengths: -large sample -risk with gestation -perinatal mortality rate calculated Limitations: coding errors -gestational age at diagnosis of stillbirth -self reported pre-pregnancy weight -confounders not adjusted	Yao 2019 [37]
US 2014	Retrospective cohort study	Washington 2003–2011 Texas 2006–2011	Singleton nonanomalous births (over 30 weeks)	2,868,482	Adjusted hazard ratio (HR) 40–42 weeks 1.33 (95 % CI 1.19–1.55)	Adjusted HR 40–42 weeks for -Class I, 2.30 (95 % CI 1.65–2.25) - Class II, 2.37 (95 % CI 2.04–3.02) -Class III, 3.30 (95 % CI 2.57–3.98) -BMI >50, 8.91 (95 % CI 1.71–5.09)		Strengths: −2 analytical approach yielded similar results -large sample size Limitations: -combined 2 databases -variable definition and coding -coding errors	Yao 2014 [38]

1.3. Timing of delivery

NICE guidance on the provision of intrapartum care suggests individual assessment for women with a booking BMI of 30–35 kg/m^2 when planning place of birth. Women with a booking BMI of >35 kg/m^2 should be offered referral to an obstetric unit [39]. The recent update of NICE guideline on Induction of Labour recommends that women who are low risk should have a discussion on induction of labour from 41^{+0} weeks to reduce some increased risks such as likelihood of caesarean section, of baby needing admission to neonatal intensive care unit and of stillbirth and neonatal death [40].

Women who are obese and pregnant are more likely to develop complications during pregnancy such as hypertension, diabetes and macrosomia. As a result, they are more likely to be offered induction of labour. In the presence of complications during pregnancy there is clear guidance that induction of labour should be offered. Obese women also have higher risk of interventions during spontaneous onset of labour. For example, labour is well recognised to be prolonged (often dysfunctional) in obese women leading to a higher intervention rate. Obese women also have a higher chance of emergency Caesarean section which may be as high as 50 % in those with class III obesity [41,42].

These above findings were replicated in a decision-analytic model created to determine optimal timing of delivery in obese women in USA. Delivery at 38 weeks' gestation was shown to prevent 203 intrauterine fetal deaths compared with expectant management until 41 weeks' gestation. Sensitivity analysis confirmed that 38 weeks remained the optimal timing. This study recommended that the ideal time to deliver obese women is 38 weeks [43]. Although the evidence for recommending induction of labour at term in obese women is not robust, we would recommend that induction at term (38–39 weeks) is considered as an option in those who are morbidly obese. The Royal College of Obstetricians and Gynaecologists Green-top Guideline states that 'elective induction of labour at term in obese women may reduce the chance of caesarean birth without increasing adverse outcomes'. [44].

1.4. Delivery - induction of labour or elective caesarean section

1.4.1. Induction of labour

Postdates pregnancies are associated with an increased risk of intrapartum and postpartum obstetric complications and higher perinatal morbidity and mortality rates [45–47]. Stillbirth rates rise exponentially after 40 weeks of gestation [34] and this is the basis for the generally accepted wisdom that in uncomplicated pregnancies, induction of labour should be considered after 41 weeks.

There is increasing evidence from several studies (in nulliparous women with and without a favourable cervix [48,49]) in women of advanced maternal age [50] and in women with a prior caesarean delivery that elective induction of labour is associated with decreased or at least similar odds of caesarean delivery and overall equivalent neonatal outcomes compared to expectant management [48–53]. A recent multicentre randomized controlled trial reported that induction of labour in nulliparous low-risk women significantly reduced the risk of caesarean delivery (18.6 % versus 22.2 %, relative risk 0.84; 95 % CI 0.76–0.93) [54]. A meta-analysis [55] of studies on elective induction at 39 weeks concluded that it reduced the rate of caesarean section, maternal infectious complications, and neonatal morbidity such as respiratory distress, hospitalization in NICU and neonatal mortality.

Since the stillbirth and perinatal mortality rates in obese and especially morbidly obese women rises significantly after 37/38 weeks [37], could elective induction of labour be offered to reduce this risk? This would be considered an option if there is evidence of benefit as well as safety. Wolfe et al. showed that obese women had higher rates of failed induction as well as higher rates of neonatal intensive care unit admission and composite neonatal morbidity [56,57]. These findings were also reported by others on obese women undergoing medical and elective inductions [58,59–61]. Composite outcomes that were reported to be higher included caesarean deliveries and postpartum complications, including haemorrhage, infections, and incisional morbidity. Interestingly in one of these studies [58], the neonates of obese women who failed to achieve a vaginal delivery after induction of labour had more respiratory morbidity, antibiotic use and admission to the neonatal intensive care unit. The validity of these studies has, however, been challenged as they either used a comparison group of normal-weight women [56] or included only women with unfavourable cervices [57]. Subsequent larger studies that compared elective induction of labour after 37 weeks in obese [62–64] and morbidly (BMI >40 kg/m^2) obese [59] women to expectant management showed that caesarean delivery, macrosomia, severe maternal morbidity, and neonatal morbidity were lower in the induction group with no change in the odds of infant and neonatal mortality.

A study by Gibbs et al. [63] comparing elective induction of labour during the 39th week of gestation versus expectant management in a large cohort of obese nulliparous and parous women found decreased odds of caesarean delivery among the nulliparous obese women but this was not the case for inductions performed at 40th or 41st weeks of gestation. There were also higher 3rd and 4th degree lacerations and lower rates of postpartum haemorrhage with elective induction of labour at 40^0–40^3 weeks among nulliparous women. These findings were consistent with the analysis by Lee et al. [62] of a large de-identified administrative California database that examined obese women undergoing elective induction of labour starting at 37 weeks. In this analysis, they showed that in nulliparous obese women induction at 37 and 39 weeks was associated with a lower risk of caesarean delivery. This reduction was also shown in parous obese women for inductions during each week starting at $\geq$ 37 weeks.

Macrosomia which is a recognised fetal complication of maternal obesity is not on its own, an indication for induction of labour. Given this known association (between maternal obesity and fetal macrosomia) [64,65], it is plausible that an elective induction of labour can reduce the risks associated with macrosomia such as shoulder dystocia? It is, however, unclear whether such an intervention will lead to a reduction in a shoulder dystocia and brachial plexus injury [66]. A few studies have investigated this. One study while showing that this was associated with reduced birth weight for all inductions <40th weeks for nulliparas and for multiparas induced at 39 weeks failed to demonstrate a reduction in the incidence of shoulder dystocia; in fact, this was increased in nulliparous women undergoing elective induction at 39 weeks. Reassuringly studies published by Lee et al. [62] Gibbs Pickens et al. [63] and

Kawakita et al. [59] did not show an increase in shoulder dystocia.

The evidence so far does appear to show that induction of labour is a safe option in obese women. The successful vaginal delivery rates that have been reported are 60 % and 90 % in nulliparous and multiparous women respectively [67], and 61.8 % for all class III obese women [68]. The RCOG Green-top Guideline states that IOL should be offered to obese pregnant women as an option of planned delivery. Hopkins et al. [69] undertook a cost effectiveness analysis of a cohort of morbidly obese who underwent induction of labour (N = 110) or had a planned CS (N = 114) at 40 weeks. The key findings were that in morbidly obese women, IOL remains cost-saving until the rate of CS following induction exceeds 70 %. The CS rate in the induction group was 53 %. A criticism of this study is that only multiparous women were included in the induction groups, and this could have been a potential source of bias. We believe that based on the evidence reviewed, elective induction of labour at 39–40 weeks of gestation confers more benefits than the risks associated with allowing pregnancies to progress beyond 41 weeks, especially in view of the significantly increased stillbirth risk. Caution should be exercised with this recommendation, and we would encourage well designed randomised prospective trials to generate robust evidence.

1.4.2. Planned (elective) caesarean section

Obesity is not an indication for caesarean section (CS); however, several studies have investigated the place of planned CS versus vaginal delivery. Subramaniam et al. [70] for example undertook a retrospective study of women with class III (morbid) obesity in which they compared IOL (N = 399) versus planned CS (N = 262). They found no differences in composite maternal or neonatal morbidity between the groups and as such concluded that in term women with class III obesity planned caesarean does not appear to reduce maternal and neonatal morbidity compared with planned induction of labour. Several of the studies cited previously compared planned induction and caesarean section and concluded that there were no significant differences in outcomes. In another study Hopkins et al. [69] reported that planned CS was associated with greater morbidity that included a surgical site infection rate of 13 % following planned CS (versus 0 % for induced vaginal delivery) and this rose to 16 % following induction and CS. It can be argued that while planned CS is not indicated in obese parturients, the potential difficulties such as logistics, delay giving adequate anaesthesia and delivery of the baby (especially where there is fetal compromise) make for a strong case to discuss planned CS as an option especially for the morbidly obese women. This is more so that the emergency CS rate is about 50 % [41,42]. It is our opinion that it is better to planned to deliver these women but taking appropriate steps to minimise the post-operative morbidity especially that of surgical site infections.

Having decided on a caesarean section (CS), the controversy in women with obesity is the type of incision on the abdomen. This is more so for those who are morbidly obese (BMI>40 kg/m^2). Options include the vertical midline incision, the Maryland incision, the Cohen incision, and Pfannenstiel incision. Most Caesarean sections are either through the Pfannenstiel incision or low transverse skin incision - both of which are more cosmetically acceptable and have lower associated morbidity.

In obese (and especially morbidly obese) women, the region below the panniculus where the transverse/Pfannenstiel incisions are made is characterised as a warm moist anaerobic environment with increased bacterial content, leading to proliferation of numerous microorganisms, producing a bacterial cesspool which promotes wound infection [71]. The use of an incision in the moist area is therefore controversial [72,73]. Two other approaches in those who are morbidly obese with a large overhanging panniculus are the

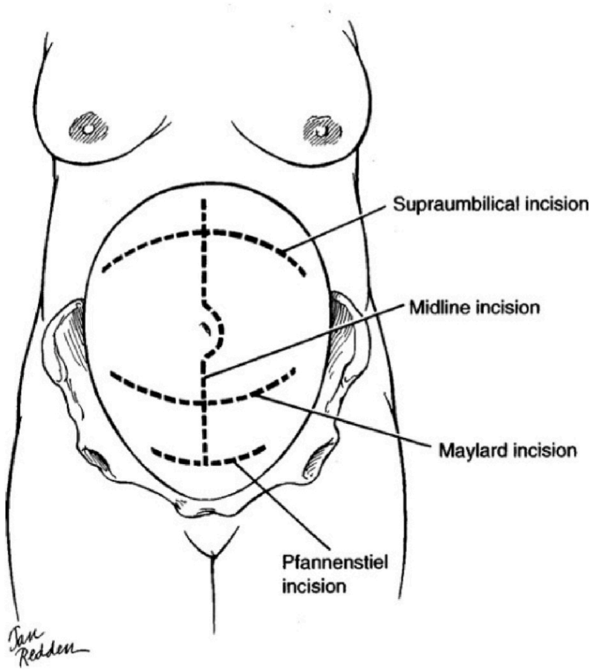

Fig. 1. Illustration of the all the various incisions on the abdomen that can be used for CS.

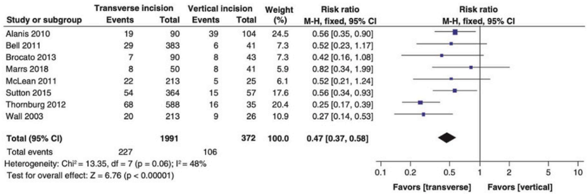

Fig. 2. Zoroob 2020 [78] Forest plot of systematic review of abdominal incisions at CS.

supra-umbilical transverse incision or supra-umbilical vertical incision (SVI) [72–74]. Fig. 1 is an illustration of the all the various incisions on the abdomen that can be used for CS.

The supra-umbilical vertical skin incisions when compared with low transverse incisions are associated with an increase in postoperative pain, postoperative atelectasis and superficial wound and fascial dehiscence [72,73]. Furthermore because the incision often overlies the uterine fundus potentially limiting the access to the lower uterine segment, there is an increased rate of classical CS. Reported rates of upper uterine incision with this vary from 14 to 23 % [71,72,74]. In subsequent pregnancies, classical uterine incisions are associated with increased morbidity that includes, intestinal obstruction and 4–9 times increased risk of uterine rupture compared to a low transverse uterine incision; with about a third of these occurring before labour and sometimes several weeks before term [72,75,76]. Vertical skin incisions are also associated with significantly increased rates of wound infection when compared with the low transverse incision (23 % versus 6 %; OR 12.4, 95 % CI) [74].

In a recent study that compared the Pfannenstiel (N = 40) and supra-umbilical vertical (N = 30) incisions in morbidly obese women (BMI>50 kg/m^2), there were no differences in immediate and delayed complications, however those who had SVI were significantly more likely to have a classical CS (60 % versus 7.5 %; $P < 0.0001$) and longer operating times.126.5 vs 102.5 min; $P < 0.01$) [77].

Zoorob et al. [78] undertook a systematic review of published studies between 2003 and 2018 comparing the maternal morbidity associated with vertical and transverse skin incisions at caesarean delivery in obese patients. Fig. 2 is a Forest Plot from this systematic review. They concluded that there was a significantly lower risk of wound complications in obese women undergoing CS with a transverse skin incision compared with a vertical skin incision (RR = 0.47, 95 % CI: 0.37–0.58; $p < 0.00001$). Sebire et al. [10] reported on wound complications in a London population study. The rate of wound complications increased with an increase of BMI from 9.2 % in women with BMI of 30–39.9 kg/m^2 (aOR: 1.4, 95 % CI: 0.99–2.0; p = 0.06), to 16.8 % in women with of BMI 40–49.9 kg/m^2 (aOR: 2.6, 95 % CI: 1.7–3.8; $p < 0.01$). The rate of wound complication in those with BMI of >50 kg/m^2 was 22.9 % (aOR: 3.0, 95 % CI: 1.9–4.9; $p < 0.01$). When all these are taken together, we can conclude that the transverse skin incision may be preferable to vertical skin incision which in obese pregnant women may be associated with lower rates of wound complications (see Fig. 3).

A variation in the transverse skin incision is one performed above the pannus (high transverse or suprapannicular incision has been investigated. Theoretically this should be associated with less wound complications because it avoids going through the pannus. This was first described by Greer et al. [80] and Gal [81]. In a retrospective case-control review of all patients who were at >150 % their ideal body weight when undergoing caesarean delivery by means of either a supraumbilical (N = 15) or a Pfannenstiel incision (N = 54) between 1989 and 1995, Houston and Rayor [82] found that postoperative morbidity in the morbidly obese women undergoing caesarean delivery did not differ between those who had the supraumbilical approach and those who had the low transverse abdominal incision. Those who had undergone the supra-umbilical incision were about 41.5 kg heavier than those who had the transverse incision. It was not until two other studies reported a tendency to reduced wound complications with this incision that clinicians took interest in this approach to CS in morbidly obese women. In a comparative case series in which all the parturients had a mean BMI of

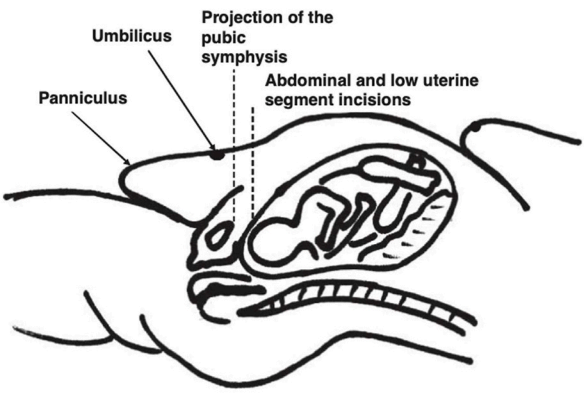

Fig. 3. Tixier 2009 [79] Illustration of the implications of panniclulus on the uterine segment.

47.7kg/m2, 13 had the subumbilical and 5 the supra-umbilical transverse incisions. Tixier et al. [79] reported quicker delivery with the suprapubic incision and no increase in classical uterine incisions and a better access to the lower uterine segment in all cases. Interestingly, only one assistant was required with the supra-umbilical transverse incision as opposed to at least 2 with the infra-umbilical incision. This was primarily because of limited exposure in the latter due to the pannus which must be retracted with the infra-umbilical transverse incision. Stewart et al. [83] reported on 20 patients of BMI 40 (range 40–61.7) kg/m^2 studied retrospectively (between 2009 and 2014), 95 % of them having an abdominal panniculus in the supine position. The median operative time was 49 min (32–70 min). Four patients (19.1 %) had a postpartum haemorrhage and 4 (19.1 %) a postpartum infectious complication, none of which were severe. They concluded that in this high-risk population of severely obese women undergoing caesarean procedures, variations in anatomy require each patient's incision choice to be individualized. For the women with a voluminous panniculus the supraumbilical skin incision appears to offer an adequate exposure to the peritoneal cavity and the lower uterine segment, therefore allowing surgeons to safely carry out the procedure. Finally, Walton et al. [84] and Dias et al. [85] respectively observed a trend showing a reduction in wound complications with the high transverse and suprapannicular type of skin incision when compared with the low transverse and infrapannicular incision [84,85]; however, the difference did not reach statistical significance. Despite these encouraging data the numbers reported on are small and therefore larger sample studies that allow for comparisons between the various abdominal incisional techniques are required. One such study is registered with Clinical Trials and is due for completion soon (Mohamed Mahmoud Arafa, Clinical Trials No) [86].

2. Summary

There is an increasing trend in stillbirth risk with rising BMI documented in literature. The reasons for this are likely to be multifactorial. Obesity has been shown not only to be associated with chronic inflammatory changes [87], sleep apnoea [88] and metabolic dysfunction but with prolonged pregnancy which could contribute to this increased risk of stillbirth after adjusting for other co-morbidities such as diabetes and hypertension. This pathophysiology is still poorly understood, and further scientific research is required. Clearly decisions regarding early delivery and interventions should take in account patient experience and morbidity.

Women who are obese have increased risks of gestational hypertension, gestational diabetes, macrosomia, and obesity related hypoventilation all of which play an important part in risk of stillbirth. Timing of delivery is challenging in these women, and they should have discussions about increased risks of stillbirth and adverse pregnancy perinatal outcomes at term. Women with morbid obesity should be informed of increased risk of stillbirth if awaiting spontaneous onset of labour beyond 40 weeks (see Fig. 4).

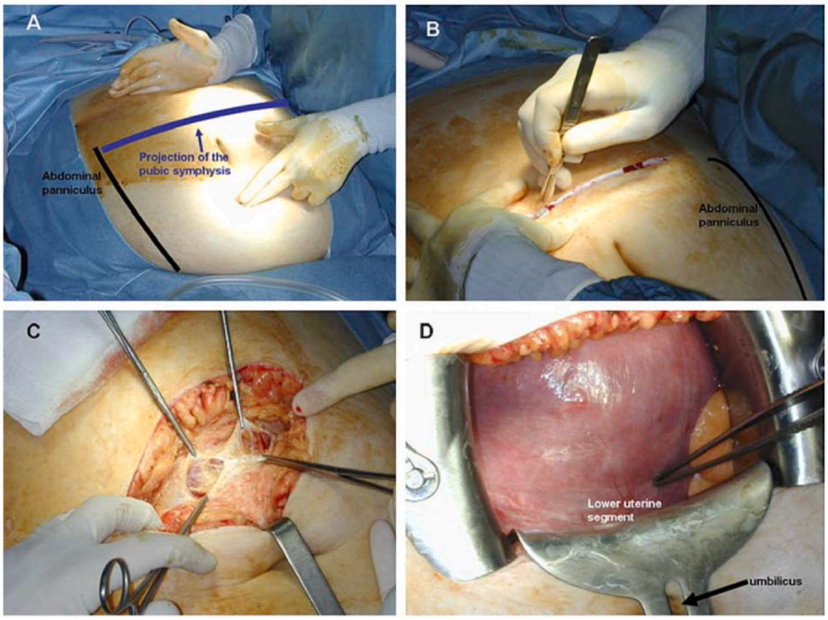

Fig. 4. Tixier 2009 [79] Operating technique for the caesarean section with a supraumbilical cutaneous incision. (A) Projection of the pubic bone which is situated above the umbilicus when the panniculus is voluminous. (B) Cutaneous incision. (C) Transversal opening of the rectus sheath. (D) Straightforward approach to the lower uterine segment.

3. Practice points

- Women with obesity are at increased risk of pregnancy related problems such as hypertension, diabetes, macrosomia, thrombosis and prolonged preganancy
- Obesity is an independent risk factor for stillbirth
- Stillbirth rises in a linear manner in women who are overweight and class I and class II obesity.
- Women with class III obesity (BMI 50 mg/kg^2) have a nonlinear rise in risk of stillbirth and this rise is from 38 weeks' gestation.
- Fetal surveillance is difficult with maternal obesity. Practitioners should be aware of limitations of these investigations antenatally and during labour
- It is good practice to individualise delivery plans in women with morbid and extreme obesity.
- Obesity on its own is not an indication for Caesarean delivery. However, risks and morbidity with emergency procedures should be discussed with women including a multidisciplinary team of specialist obstetricians, obstetric anaesthetists and midwives.

4. Research agenda

There is increasing evidence that obesity is an independent risk factor for stillbirth. Addressing best options for fetal surveillance in these women and further developments in this field can enhance and improve perinatal outcomes. Population based studies have reported an increased risk of stillbirth rising with pre pregnancy BMI. Whilst induction of labour can reduce late onset stillbirth the optimal timing is still unclear due to lack of randomised controlled trials. Conducting research in this way may be difficult especially with recruitment of women into these trials given the nature of randomisation required. Future research should be aimed at providing answers to determine best methods of fetal surveillance, timing and method of delivery in women with obesity aiming to reduce perinatal adverse outcomes while balancing maternal morbidity rates.

Declaration of competing interest

The authors have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bpobgyn.2023.102425.

References

[1] WHO News 2021. https://www.who.int/news-room/facts-in-pictures/detail/6-facts-on-obesity.
[2] https://www.worldobesityday.org/resources/entry/world-obesity-atlas-2022.
[3] Current Status and Response to the Global Obesity Pandemic: Proceedings of a Workshop: Global Trends in Obesity. https://www.ncbi.nlm.nih.gov/books/NBK544130/.
[4] American College of Obstetricians and Gynecologists. ACOG practice bulletin No 156: obesity in pregnancy. Obstet Gynecol 2015;126:1321–2.
[5] Butwick A, Bentley J, Leonard S, Carmichael S, El-Sayed Y, Stephansson O, et al. Prepregnancy maternal body mass index and venous thromboembolism: a population-based cohort study. BJOG An Int J Obstet Gynaecol 2019;126:581–8.
[6] Smid M, Keaney M, Stamilo D. Extreme obesity and post-cesarean wound complications in maternal-Fetal Medicine unit Cesarean registry. Am J Perinatol 2015;32:1336–41.
[7] Conner S, Verticchio J, Tuuli M, Odibo A, Macones G, Cahill A. Maternal obesity and risk of post-cesarean wound complications. Am J Perinatol 2014;31:299–304.
[8] Aune D, Saugstad OD, Henriksen T, Tonstad S. Maternal body mass index and the risk of fetal death, stillbirth, and infant death: a systematic review and meta-analysis death: a systematic review and meta-analysis. JAMA 2014;311:1536–1546*.
[9] Bloomfield FH, Oliver MH, Hawkins P, Campbell M, Phillips DJ, Gluckman PD, et al. A periconceptional nutritional origin for noninfectious preterm birth. Science 2003;300:606.
[10] Sebire NJ, Jolly M, Harris S, Regan L, Robinson S. Is maternal underweight really a risk factor for adverse pregnancy outcome? A population-based study in London. BJOG 2001;108:61–6.
[11] Critchely HOD, Bennett P, Thornton S. Control of the length of gestation: lessons from women, Chapter 2. In: Press R, editor. Preterm birth. Study group publication. London: RCOG Press; 2004. p. 23.
[12] Denison F, Price J, Graham C, Wild S, Liston W. Maternal obesity, length of gestation, risk of postdates pregnancy and spontaneous onset of labour at term. BJOG An Int J Obstet Gynaecol 2008;115(6):720–5.
[13] Lauth C, Huel J, Dolley P, Thibon P, Dreyfus M. Maternal obesity in prolonged pregnancy: labor, mode of delivery, maternal and fetal outcomes. Journal of Gynecology Obstetrics and Human Reproduction 2021:101909. https://doi.org/10.1016/j.jogoh.2020.101909.
[14] Kiran TSU, Hemmadi S, Bethel J, Evans J. Outcome of pregnancy in a woman with an increased body mass index. BJOG An Int J Obstet Gynaecol 2004;112:768–72 [14].
[15] Stotland NE, Washington AE, Caughey AB. Pre-pregnancy body mass index and the length of gestation at term. Am J Obstet Gynecol 2007;197:378. e1–378.e5.
[16] Johnson JW, Longmate JA, Frentzen B. Excessive maternal weight and pregnancy outcome. Am J Obstet Gynecol 1992;167:353–70.
[17] Johnson JWC, Longmate JA, Frentzen B. Excessive maternal weight gain and pregnancy outcome. Am J Obstet Gynecol 1992;167:353–72.
[18] Zhou XL. [Clinical analysis of the relation between maternal body weight and high risk factors during pregnancy and delivery]. Zhonghua Fu Chan Ke Za Zhi 1993;28(397–8):441.
[19] Riley SC, Walton JC, Herlick JM, Challis JR. The localization and distribution of corticotropin-releasing hormone in the human placenta and fetal membranes throughout gestation. J Clin Endocrinol Metab 1991;72:1001–7.

[20] Mercer BM, Macpherson CA, Goldenberg RL, Goepfert AR, Haugel-De Mouzon S, Varner MW, et al. Are women with recurrent spontaneous preterm births different from those without such history? Am J Obstet Gynecol 2006;194:1176–84.
[21] Inder WJ, Prickett TC, Ellis MJ, Hull L, Reid R, Benny PS, et al. The utility of plasma CRH as a predictor of preterm delivery. J Clin Endocrinol Metab 2001;86: 5706–10.
[22] McLean M, Bisits A, Davies J, Woods R, Lowry P, Smith R. A placental clock controlling the length of human pregnancy. Nat Med 1995;1:460–3.
[23] Ljung T, Andersson B, Bengtsson BA, Bjorntorp P, Marin P. Inhibition of cortisol secretion by dexamethasone in relation to body fat distribution: a dose-response study. Obes Res 1996;4:277–82.
[24] Ljung T, Holm G, Friberg P, Andersson B, Bengtsson BA, Svensson J, et al. The activity of the hypothalamic-pituitary-adrenal axis and the sympathetic nervous system in relation to waist/hip circumference ratio in men. Obes Res 2000;8:487–95.
[25] Jessop DS, Dallman MF, Fleming D, Lightman SL. Resistance to glucocorticoid feedback in obesity. J Clin Endocrinol Metab 2001;86:4109–14.
[26] Strain GW, Zumoff B, Kream J, Strain JJ, Levin J, Fukushima D. Sex difference in the influence of obesity on the 24 hr mean plasma con- centration of cortisol. Metabolism 1982;31:209–12.
[27] Emanuel RL, Robinson BG, Seely EW, Graves SW, Kohane I, Saltzman D, et al. Corticotrophin releasing hormone levels in human plasma and amniotic fluid during gestation. Clin Endocrinol 1994;40:257–62.
[28] Smith R, Mesiano S, McGrath S. Hormone trajectories leading to human birth. Regul Pept 2002;108:159–64.
[29] UNICEF. A Neglected Tragedy. The global burden of stillbirth. October 2020.
[30] Lawn JE, Blencowe H, Waiswa P, Amouzou A, Mathers C, Hogan D, Flenady V, Frøen JF, Qureshi ZU, Calderwood C, Shiekh S, Jassir FB, You D, McClure EM, Mathai M, Cousens S. Lancet Ending Preventable Stillbirths Series study group; Lancet Stillbirth Epidemiology investigator group. Stillbirths: rates, risk factors, and acceleration towards 2030. Lancet 2016;387:587–603*.
[31] Flenady V, Koopmans L, Middleton P, Frøen JF, Smith GC, Gibbons K, Coory M, Gordon A, Ellwood D, McIntyre HD, Fretts R, Ezzati M. Major risk factors for stillbirth in high-income countries: a systematic review and meta-analysis. Lancet 2011;377:1331. -40*.
[32] Draper ES, Gallimore ID, Smith LK, Matthews RJ, Fenton AC, Kurinczuk JJ, Smith PW, Manktelow BN, on behalf of the MBRRACE-UK Collaboration. MBRRACE-UK perinatal mortality surveillance report, UK perinatal deaths for births from january to december 2020: tables and figures. In: Leicester: the infant mortality and morbidity studies. Department of Health Sciences, University of Leicester; 2022.
[33] Pre-pregnancy weight and the risk of stillbirth and neonatal death Janni Kristensen, Mogens Vestergaard, Kirsten Wisborg, Ulrik Kesmodel, Niels Jørgen Secher First published: 19 February 2005 https://doi.org/10.1111/j.1471-0528.2005.00437.
[34] Akselsson A, Rossen J, Storck-Lindholm E, Rådestad I. Prolonged pregnancy and stillbirth among women with overweight or obesity - a population-based study in Sweden including 64,632 women. BMC Pregnancy Childbirth 2023;23:21.
[35] Chu SY, Kim SY, Lau J, Schmid CH, Dietz PM, Callaghan WM, Curtis KM. Maternal obesity and risk of stillbirth: a metaanalysis. Am J Obstet Gynecol 2007;197: 223–8. *.
[36] Eberle A, Czuzoj-Shulman N, Abenhaim HA. Timing of delivery in obese women and risk of stillbirth. J Matern Fetal Neonatal Med 2022;35:7771–7.
[37] Yao R, Schuh BL, Caughey AB. The risk of perinatal mortality with each week of expectant management in obese pregnancies. J Matern Fetal Neonatal Med 2019 Feb;32(3):434–41. https://doi.org/10.1080/14767058.2017.1381903. Epub 2017 Sep 27. PMID: 28922969.
[38] Yao R, Ananth CV, Park BY, et al. Obesity and the risk of stillbirth: a population-based cohort study. Am J Obstet Gynecol 2014;210:457.e1–9.
[39] Intrapartum care for healthy women and babies. NICE Clinical Guideline [CG190]. Published: 3 December 2014. www.nice.org.uk/guidance/cg190.
[40] Inducing Labour. NICE Guideline [NG207]. Published: 4 November 2021. www.nice.org.uk/guidance/ng207.
[41] Poobalan AS, Aucott LS, Gurung T, Smith WC, Bhattacharya S. Obesity as an independent risk factor for elective and emergency caesarean delivery in nulliparous women–systematic review and meta-analysis of cohort studies. Obes Rev 2009;10:28–35*.
[42] Paidas Teefey C, Reforma L, Koelper NC, Sammel MD, Srinivas SK, Levine LD, Durnwald CP. Risk factors associated with cesarean delivery after induction of labor in women with class III obesity. Obstet Gynecol 2020;135:542–9.
[43] Lee Vanessa RBA, Niu Brenda BA, Kaimal Anjali MD, Little Sarah MD, Nicholson Jim MD, Caughey Aaron B. Optimal timing of delivery in obese women: a decision analysis. Obstet Gynecol May 2014;123:152S–3S. https://doi.org/10.1097/01.AOG.0000447144.44382.5a.
[44] Denison FC, Aedla NR, Keag O, Hor K, Reynolds RM, Milne A, et al., on behalf of the Royal College of Obstetricians and Gynaecologists. Care of Women with Obesity in Pregnancy. Green-Top Guideline No. 72. BJOG 2018.
[45] Nakling J, Backe B. Pregnancy risk increases from 41 weeks of gestation. Acta Obstet Gynecol Scand 2006;85:663–8.
[46] Cucco C, Osborne MA, Cibils LA. Maternal-fetal outcomes in pro- longed pregnancy. Am J Obstet Gynecol 1989;161:916–20.
[47] Hollis B. Prolonged pregnancy. Curr Opin Obstet Gynecol 2002;14:203–7.
[48] Osmundson SS, Ou-Yang RJ, Grobman WA. Elective induction compared with expectant management in nulliparous women with a favorable cervix. Obstet Gynecol 2010;116:601–5.
[49] Osmundson SS, Ou-Yang RJ, Grobman WA. Elective induction compared with expectant management in nulliparous women with an unfavorable cervix. Obstet Gynecol 2011;117:583–7.
[50] Walker KF, Bugg GJ, Macpherson M, McCormick C, Grace N, Wildsmith C. Randomized trial of labor induction in women 35 Years of age or older. N Engl J Med 2016;374:813–22.
[51] Palatnik A, Grobman WA. Induction of labor versus expectant management for women with a prior cesarean delivery. 1. Am J Obstet Gynecol 2015;212:358. e1–6.
[52] Stock S, Ferguson E, Duffy A, Ford I, Chalmers J, Norman JE. Outcomes of elective induction of labour compared with expectant management: population based study. BMJ 2012;344:e2838.
[53] Caughey AB, Nicholson JM, Cheng YW, Lyell DJ, Washington AR. Induction of labor and cesarean delivery by gestational age. Am J Obstet Gynecol 2006;195: 700–5.
[54] Grobman WA, Rice MM, Reddy UM, Tita ATN, Silver RM, Mallett G, Hill K, et al. Induction versus expectant management in low-risk nulliparous women. N Engl J Med 2018;379:513–23.
[55] Grobman WA, Caughey AB. Elective induction of labor at 39 weeks compared with expectant management: a meta-analysis of cohort studies. Am J Obstet Gynecol 2019;221:304–10. https://doi.org/10.1016/j.ajog.2019.02.046. Epub 2019 Feb 25. PMID: 30817905.
[56] Wolfe KB, Rossi RA, Warshak CR. The effect of maternal obesity on the rate of failed induction of labor. Am J Obstet Gynecol 2011;205:128. e1–7.
[57] Wolfe H, Timofeev J, Tefera E, Desale S, Driggers RW. Risk of cesarean in obese nulliparous women with unfavorable cervix: elective induction vs expectant management at term. Am J Obstet Gynecol 2014;211:53. e1–5.
[58] Arrowsmith S, Wray S, Quenby S. Maternal obesity and labour complications following induction of labour in prolonged pregnancy: obesity and prolonged pregnancy. BJOG An Int J Obstet Gynaecol 2011;118:578–588*.
[59] Kawakita T, Iqbal SN, Huang CC, Reddy UM. Nonmedically indicated induction in morbidly obese women is not associated with an increased risk of cesarean delivery. Am J Obstet Gynecol 2017;217:451. e1–451.e8.
[60] O'Dwyer V, O'Kelly S, Monaghan B, Rowan A, Farah N, Turner MJ. Maternal obesity and induction of labor. Acta Obstet Gynecol Scand 2013;92:1414–8.
[61] Robinson CJ, Hill EG, Alanis MC, Chang EY, Johnson DD, Almeida JS. Examining the effect of maternal obesity on outcome of labor induction in patients with preeclampsia. Hypertens Pregnancy 2010;29:446–56.
[62] Lee VR, Darney BG, Snowden JM, Main EK, Gilbert W, Chung J, et al. Term elective induction of labour and perinatal outcomes in obese women: retrospective cohort study. BJOG 2016;123:271–8.
[63] Gibbs-Pickens CM, Kramer MR, Howards PP, Badell ML, Caughey AB, Hogue CJ. Term elective induction of labor and pregnancy outcomes among obese women and their offspring. Obstet Gynecol 2018;131:12–22.
[64] Sewell MF, Huston-Presley L, Super DM, Catalano P. Increased neonatal fat mass, not lean body mass, is associated with maternal obesity. Am J Obstet Gynecol 2006;195:1100–3.

[65] American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Obstetrics. Practice bulletin No. 173: fetal macrosomia. Obstet Gynecol 2016;128:e195–209.
[66] Hull HR, Dinger MK, Knehans AW, Thompson DM, Fields DA. Impact of maternal body mass index on neonate birthweight and body composition. Am J Obstet Gynecol 2008;198:416. e1–6.
[67] Caughey AB, Sundaram V, Kaimal AJ, Gienger A, Cheng YW, McDonald KM, Shaffer BL, Owens DK, Bravata DM. Systematic review: elective induction of labor versus expectant management of pregnancy. W53-63 Ann Intern Med 2009;151:252–63. https://doi.org/10.7326/0003-4819-151-4-200908180-00007. PMID: 19687492.
[68] Ellis JA, Brown CM, Barger B, Carlson NS. Influence of maternal obesity on labor induction: a systematic review and meta-analysis. J Midwifery Wom Health 2019 Jan;64(1):55–67. https://doi.org/10.1111/jmwh.12935. Epub 2019 Jan 16. PMID: 30648804; PMCID: PMC6758543*.
[69] Hopkins MK, Grotegut CA, Swamy GK, Myers ER, Havrilesky LJ. Induction of labor versus scheduled cesarean in morbidly obese women: a cost-effectiveness analysis. Am J Perinatol 2019;36:399–405.
[70] Subramaniam A, Chapman V, Goss AR, Alvarez MD, Reese C, Edwards KE. Mode of delviery in women with class III obesity: planned cesarean compared with induction of labour. Am J Obstet Gynecol 2014;211. 700.e1-9*.
[71] Morrow CP, Hernandez WL, Townsend DE, DiSaia PJ. Pelvic celiotomy in the obese patient. American Journal of Obstetrics and Gynecology 1977;127(4):335–9. ISN 0002-9378, https://doi.org/10.1016/0002-9378(77)90486-0.
[72] Bell J, Bell S, Vahratian A, Awonuga AO. Abdominal surgical incisions and perioperative morbidity among morbidly obese women undergoing cesarean delivery. Eur J Obstet Gynecol Reprod Biol 2011;154:16–9.
[73] Alanis MC, Villers MS, Law TL, Steadman EM, Robinson CJ. Complications of cesarean delivery in the massively obese parturient. Am J Obstet Gynecol 2010; 203. e1-7*.
[74] Wall PD, Deucy EE, Glantz JC, Pressman EK. Vertical skin incisions and wound complications in the obese parturient. Obstet Gynecol 2003;102:952–6.
[75] Lao TT, Halpern SH, Crosby ET, Huh C. Uterine incision and maternal blood loss in preterm cesarean section. Arch Gynecol Obstet 1993;252:113–7.
[76] Carswell W. The current status of classical cesarean section. Scot Med J 1973;18:105–8. 1977;127:335-108.
[77] Seif KE, Goetzinger K, Turan O. Choosing the optima incision for cesarean delviery in patients with morbid obesity. Am J Obstet Gynecol 2021:S322–3.
[78] Zoorob D, Zarudskaya O, Van Hook J, Moussa HN. Maternal morbidity associated with skin incision type at cesarean delivery in obese patients: a systematic review. Future Sci OA 2020 Dec 18;7(3). https://doi.org/10.2144/fsoa-2020-0160. FSO669.PMID: 33552545; PMCID: PMC7850001.
[79] Tixier H, Gole SE, Thouvenot NEC, Coulange LN, Peyronel C, Filipuzzi L, Sagot P, Douvier S. Cesarean section in morbidly obese women: supra or subumbilical transverse incision? Acta Obstetricia et Gynecologica 2009;88:1049–52.
[80] Greer BE, Cain JM, Figge DC, Shy KK, Tamimi HK. Supraumbilical upper abdominal midline incision for pelvic surgery in the morbidly obese patient. Obstet Gynecol 1990;76:471–3.
[81] Gal D. A supraumbilical incision for gynecologic neoplasms in the morbidly obese patient. J Am Coll Surg 1994;179:18–20.
[82] Houston MC, Raynor BD. Postoperative morbidity in the morbidly obese parturient woman: supraumbilical and low transverse abdominal approaches. Am J Obstet Gynecol 2000;182:1033–5.
[83] Stewart Z, Dolley P, Beucher G, Villot A, Dreyfus M. Supraumbilical transverse incision for cesarean section in severely obese patients: the experience of a French hospital from 2009 to 2014. Open J Obstet Gynecol 2017;7:1024–34.
[84] Walton R, Shnaekel K, Ounpraseuth S, Napolitano P, Magann E. High transverse skin incisions may reduce wound complications in obese women having cesarean sections: a pilot study. J Matern Fetal Neonatal Med 2017;32:1–11.
[85] Dias M, Dick A, Reynolds RM, Lahti-Pulkkinen M. Denison FC Predictors of surgical site skin infection and clinical outcome at cesarean section in the very severely obese: a retrospective cohort study. PLoS One 2019;14:e0216157 (2019)*.
[86] Arafa Mohamed. ransverse Supraumbilical versus Pfannenstiel Incision for Cesarean Section in Morbidly Obese Women. A Randomised Controlled Trial registered with ClinicalTrials.gov identifier: NCT05385276. Still recruiting and due for completion. 2023.
[87] Kim CJ, Romero R, Chaemsaithong P, et al. Chronic inflammation of the placenta: definition, classification, pathogenesis, and clinical significance. Am J Obstet Gynecol 2015;213:S53–69.
[88] Louis J, Auckley D, Miladinovic B, et al. Perinatal outcomes associated with obstructive sleep apnea in obese pregnant women. Obstet Gynecol 2012;120: 1085–92.