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ORIGINAL ARTICLE

The impact of body mass index on labour management and mode of delivery: A retrospective matched cohort study

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Aim: This study aims to examine the association between body mass index (BMI) and mode of delivery, progression of labour, and intrapartum interventions.

Methods: This was a retrospective matched cohort study including Class III obese (BMI ≥40 kg/m^2) and normal BMI (BMI <25 kg/m^2) women planning a vaginal birth who had a live, singleton delivery from January 2015 to December 2018. Patients were matched (1:1) based on age, gestational age, parity, onset of labour and birth weight. The primary outcome was caesarean delivery (CD). Secondary outcomes were delivery outcomes, intrapartum management and interventions. Rates of each outcome were compared with matched analysis, and duration of labour with time-to-event analysis.

Results: We studied two groups of 300 pregnant women. The CD rate was significantly higher for obese women than the normal BMI cohort (19.3% vs 13.3%; risk ratio (RR) 1.43, 95% CI 1.02–1.98, $P = 0.035$). Cervical dilation prior to CD for failure to progress was slower in obese than normal BMI (0.04 vs 0.16 cm/h). The obese cohort had a longer duration of labour in those who underwent induction (13.70 vs 11.48 h, $P = 0.024$). Intrapartum intervention rates were higher for obese women, with significant differences in rates of fetal scalp electrodes (72.7% vs 22.7%, RR 3.20, 95% CI 2.58–3.99, $P < 0.001$), intrauterine pressure catheters (18.3% vs 0%, $P < 0.001$), epidural analgesia (44.0% vs 37.0%, RR 1.20, 95% CI 1.01–1.44, $P = 0.040$) and fetal scalp lactate sampling (8.0% vs 3.0%, RR = 2.67, 95% CI 1.33–5.33, $P = 0.004$).

Conclusion: Class III obesity is associated with an increased risk of CD and intrapartum interventions.

KEYWORDS

BMI, body mass index, caesarean delivery, intrapartum management, mode of delivery

INTRODUCTION

The increasing prevalence of obesity among women of reproductive age has had a significant impact on safe obstetric practice. Maternal obesity (body mass index (BMI) > 30 kg/m^2) has a well-established relationship with pregnancy and intrapartum complications. Increased BMI has been associated with higher rates of adverse pregnancy complications, including hyperglycaemic

disorders, hypertensive disorders, post-dates pregnancies, fetal macrosomia and perinatal mortality.[1,2] It has also been linked to higher rates of induction of labour, and a longer duration of labour.[3–5] During labour, obese women are more likely to require multiple induction devices, oxytocin administration, and epidural analgesia.[4–6] In relation to delivery, increased BMI is associated with higher rates of emergency caesarean delivery (CD), higher rates of failed induction of labour, and post-partum complications.[5–9]

Many of these pregnancy complications often associated with maternal obesity are also known to increase the rates of induction of labour, risk of failed induction and emergency caesarean deliveries.[1,9] Within the current literature, limited studies have been able to investigate the independent effect of obesity when examining its association with labour management and mode of delivery. Therefore, the quantifiable role of maternal BMI as an independent risk factor contributing to rates of CD remains poorly understood.[3–5,7,9–14] Furthermore, it can be difficult to assess the degree of bias in clinical decision-making for obese women, which could potentially be reflected in higher rates of interventions and earlier decision for caesarean section delivery.[10]

This study aims to examine the independent association between maternal Class III obesity on the progression and management of labour, while controlling for factors such as age, parity, onset of labour, and birth weight. We also aim to investigate the association of maternal obesity with the extent of practitioner intervention in labour, including timing of CD and use of intrapartum interventions.

MATERIALS AND METHODS

Study population and sample size calculation

This is a retrospective matched cohort study, including women with singleton pregnancies who birthed between January 2015 and December 2018 within one tertiary hospital and two secondary hospitals in Melbourne, Australia. The population was selected using a pre-specified query on the Birthing Outcomes System® (BOS, version 6.0.1, Management Consultants and Technology Services, Caulfield, Victoria, Australia).

To adjust for potential confounding by age and the potential impact of gestational age, parity and fetal size on the outcome of CD, women of Class III obesity (BMI ≥ 40 kg/m^2) were matched (1:1) with women of normal BMI (BMI < 25 kg/m^2) based on age (±12 months), gestational age (±0.5 week), parity (nulliparous/multiparous), onset of labour (spontaneous/induced) and birth weight (±250 g). The matching process was achieved using a pool of possible controls from within the Birthing Outcomes System®. Women with previous CD, multiple pregnancies, deliveries before 36 weeks, non-cephalic presentations, stillbirths, maternal age <18 years and elective CD were excluded from this study. A sample size of 532 women (266 pairs) was calculated to detect a 50% increase in the risk of CD in the obese group, assuming a baseline risk of 15% for CD for women with normal BMI based on local data, allowing for a type I error of 5% and a type II error of 20%. The sample size calculation was made using Stata (Stata, version 17, StataCorp LLC, College Station, Texas, USA).

To allow for sufficiently powered subgroup analyses, the matched pairs studied were evenly selected depending on parity, with 150 pairs of nulliparous women, and 150 pairs of multiparous women. Within these parity subgroups, the matched pairs were then evenly divided between spontaneous and induction of labour.

Ethics approval

The study complied with the National Health and Medical Research Council (NHMRC) 2014 Ethical Considerations in Quality Assurance and Evaluation Activities[8] and was approved by Monash Health Human Research Ethics Committee (Ref: RES-20-000-822Q-70082).

Data collection

Retrospective data were collected from BOS, K2 Medical Systems Limited (K2 Athena, version 4.1.50612.1: Plymouth, United Kingdom), and InfoMedix Scanned Medical Records (InfoMedix, 2017: Melbourne, Australia). Data collected through individual chart review included time and date of admission, rupture of membranes, birth, delivery details (mode and indication), cervical dilation at CD, vaginal examination timings and cervical dilation at each examination, and intrapartum interventions (epidural analgesia, fetal scalp electrode, intrauterine pressure catheter (IUPC), fetal scalp lactate measurement, terbutaline use, oxytocin labour augmentation).

Statistical analysis

The primary outcome measure was the relationship between obesity and rate of CD. Secondary outcomes included rates of CD for each indication for delivery (failure to progress, fetal/maternal concern, and maternal requests), rates of instrumental delivery, timing of CD (cervical dilation at time of decision for CD, rate of cervical change (cm/h) prior to decision for CD), intrapartum intervention rate, and duration of labour. Categorical variables were expressed in absolute values and percentages, and compared between groups using McNemar's test. Continuous variables were expressed in median and interquartile range, and analysed using Wilcoxon or paired *t*-test, depending on the distribution of the data. The results are reported in line with STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.

Kaplan–Meier survival estimates were used to assess the time to birth with censoring of CD, and the groups were compared with the log-rank test. Time to birth in women who laboured spontaneously was measured from the time of admission to birth, while in those undergoing induction of labour it was measured from the time of amniotomy to birth. Utilising the timepoint of establishment of labour in calculating duration of labour was avoided in order to minimise potential human error and clinician bias. Statistical analyses were performed using Stata (Stata, version 17, StataCorp LLC, College Station, Texas, USA).

RESULTS

We studied 600 women with singleton pregnancies, of whom 300 were obese and 300 had normal BMI. Of those included, 300 (50%) were primiparous and 300 (50%) were multiparous. For both primiparous and multiparous groups, half had spontaneous labour and half had their labour induced (IOL). The obese cohort and the normal BMI cohort were comparable for mean maternal age (29.9 vs 29.9 years), mean gestational age (39.5 vs 39.5 weeks) and birthweight (3541.9 vs 3507.6 g) in keeping with the matching process (Table S1). The mean BMI for the obese cohort was 44.3 kg/m^2, and the mean BMI for the normal BMI cohort was 22.0 kg/m^2.

CD

CD rate was significantly higher for the obese cohort as compared with normal BMI cohort (19.3% vs 13.3%; risk ratio (RR) 1.43, 95% CI 1.02–1.98, $P = 0.035$; Table 1). The rates of CD were higher in the obese cohort for both primigravid (32.0% vs 24.0%; RR 1.31, 95% CI 0.92–1.85, $P = 0.131$) and multigravida women (6.7% vs 2.7%; RR 2.50, 95% CI 0.85–7.31, $P = 0.083$), although these subgroup differences did not reach statistical significance. The rate of instrumental deliveries was significantly lower in the obese cohort (16.7%) compared with the normal BMI (24.0%) cohort (16.7% vs 24.0%; RR 0.73, 95% CI 0.52–1.01, $P = 0.055$).

In relation to indication for CD, the obese cohort had higher rates of CD for both failure to progress (11.0% vs 8.7%, RR 1.27, 95% CI 0.82–1.97, $P = 0.287$) and fetal/maternal concern (8.0% vs 4.7%, RR 1.60, 95% CI 0.87–2.95, $P = 0.132$) as compared with the normal BMI cohort, but these differences were not statistically significant (Table 2). The median cervical dilation at the time of CD was also lower in the obese group as compared with the normal BMI group (4 vs 6 cm, $P = 0.056$) (Fig. 1).

CD for failure to progress

When further investigating CD for failure to progress, the mean cervical change within the 4 h preceding CD was found to be lower in obese as compared with normal BMI women (0.04 vs 0.16 cm/h) The median cervical dilation at the time of CD for failure to progress was lower in obese compared with normal BMI women (5 vs 7 cm, $P = 0.125$) (Fig. 2). Although not statistically different, the total dosage of oxytocin used in obese women was also slightly higher than in normal BMI women (18.70 vs 17.49 IU, $P = 0.807$), as well as the mean oxytocin rate (1.14 vs 1.10 IU/h) prior to CD for failure to progress (Table 2).

Labour duration

The progress of labour was examined through Kaplan–Meier survival analysis of time-to-delivery, censoring births that occurred by CD. Of those women who underwent IOL, the obese cohort also had a longer duration of labour ($P = 0.024$). No significant difference in labour duration was seen for women who laboured spontaneously ($P = 0.554$).

Intrapartum interventions

Regarding intrapartum monitoring, the mean interval between vaginal examinations was shorter for obese as compared to normal BMI women (3.9 vs 4.6 h) excluding those without vaginal examinations (19 for obese, 22 for normal BMI). There

TABLE 1 Mode of delivery among women with obesity and matched normal BMI controls

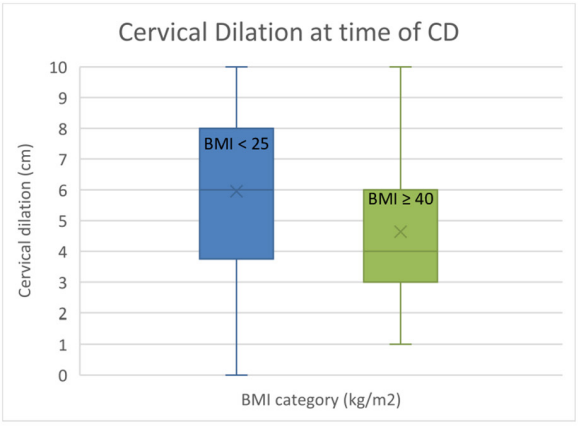
	BMI ≥40 kg/m^2 ($n = 300$)			BMI < 25 kg/m^2 ($n = 300$)			
	NVD	AVD	CD	NVD	AVD	CD	RR for CD (95% CI) *P*-value
Total, *n* (%)	192 (64.0)	50 (16.7)	58 (19.3)	188 (62.7)	72 (24.0)	40 (13.3)	1.43 (1.02–1.98) $P = 0.035$
Nulliparous, *n* (%)	64 (42.7)	38 (25.3)	48 (32.0)	54 (36.0)	60 (40.0)	36 (24.0)	1.31 (0.92–1.85) $P = 0.131$
Spontaneous, *n* (%)	39 (52.0)	22 (29.3)	14 (18.6)	35 (46.7)	31 (41.3)	9 (12.0)	1.44 (0.67–3.12) $P = 0.346$
IOL, *n* (%)	25 (33.3)	16 (21.3)	34 (45.3)	19 (25.3)	29 (38.7)	27 (36.0)	1.26 (0.86–1.85) $P = 0.237$
Multiparous, *n* (%)	128 (85.3)	12 (8.0)	10 (6.7)	134 (89.3)	12 (8.0)	4 (2.7)	2.50 (0.85–7.31) $P = 0.083$
Spontaneous, *n* (%)	70 (93.3)	3 (4.0)	2 (2.7)	69 (92.0)	5 (6.7)	1 (1.3)	2.00 (0.18–22.06) $P = 0.564$
IOL, *n* (%)	58 (77.3)	9 (12.0)	8 (10.7)	65 (86.7)	7 (9.3)	3 (4.0)	2.67 (0.80–8.86) $P = 0.096$

Data given as number and percentages.
AVD, assisted (instrumental) vaginal delivery; BMI, body mass index; CD, caesarean delivery; CI, confidence interval; IOL, induction of labour; NVD, normal vaginal delivery; RR, risk ratio.

TABLE 2 CDs indicated for failure to progress among women with obesity and matched normal BMI controls

	BMI	
	≥40 kg/m^2 (n = 33)	<25 kg/m^2 (n = 26)
Indication for CD		
Failure to progress, n (%)	33 (11.0)	26 (8.7)
Fetal/maternal concern, n (%)	22 (7.3)	13 (4.3)
Maternal request, n (%)	3 (1.0)	1 (0.3)
Oxytocin use in CD for FTP		
Proportion using oxytocin, n (%)	31 (93.9)	25 (96.2)
Total oxytocin dosage, IU, mean (SD)	18.46 (15.64)	17.07 (14.74)
Total duration of oxytocin, h, mean (SD)	13.51 (6.89)	13.06 (7.10)
Oxytocin rate, IU/h, mean (SD)	1.14 (0.64)	1.08 (0.66)
Cervical dilation 4 h prior to CD for FTP		
Rate of dilation, cm/h, mean (SD)	0.04 (0.13)	0.16 (0.51)

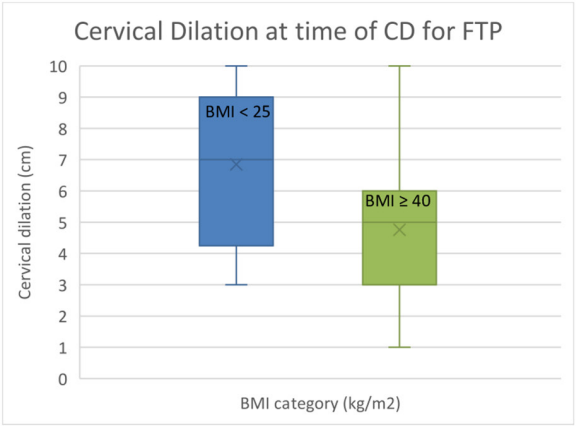
BMI, body mass index; CD, caesarean delivery; FTP, failure to progress; SD, standard deviation.



	BMI (kg/m^2)	
	≥ 40	< 25
Min	1	0
Q1	3	3.75
Median	4	6
Mean	4.64	5.95
Q3	6	8
Max	10	10

BMI: body mass index, CD: caesarean delivery

FIGURE 1 Cervical dilation at the time of CD among women with obesity and matched normal BMI controls (P-value = 0.056). BMI, body mass index; CD, caesarean delivery.



	BMI (kg/m^2)	
	≥ 40	< 25
Min	1	3
Q1	3	4.25
Median	5	7
Mean	4.76	6.85
Q3	6	9
Max	10	10

BMI: body mass index, CD: caesarean delivery FTP: failure to progress

FIGURE 2 Cervical dilation at the time of CD for FTP among women with obesity and matched normal BMI controls (P-value = 0.125). BMI, body mass index; CD, caesarean delivery; FTP, failure to progress.

TABLE 3 Intrapartum interventions among women with obesity and matched normal BMI controls

	BMI		
	≥40 kg/m^2 (*n* = 300)	<25 kg/m^2 (*n* = 300)	*P*-value
Epidural analgesia, *n* (%)	132 (44.0%)	111 (37.0%)	0.08
Fetal scalp electrode, *n* (%)	218 (72.7%)	68 (22.7%)	<0.0001
Intrauterine pressure catheter, *n* (%)	55 (18.3%)	0 (0.0%)	<0.0001
Fetal scalp lactate, *n* (%)	24 (8.0%)	9 (3.0%)	0.007
Terbutaline, *n* (%)	12 (4.0%)	10 (3.3%)	0.66

BMI, body mass index.

were significantly higher rates of fetal scalp electrode use in obese compared with normal BMI women (72.7 vs 22.7%; RR 3.20, 95% CI 2.58–3.99, $P < 0.001$), as was the case for use of intrauterine pressure catheters (18.3 vs 0.0%; $P < 0.001$) and fetal scalp lactate sampling (8.0 vs 3.0%; RR 2.67, 95% CI 1.33–5.33, $P = 0.004$) (Table 3).

Terbutaline administration for uterine hyperstimulation was comparable in obese and normal BMI women (4 vs 3.33%; RR 1.33, 95% CI 0.56–3.16, $P = 0.514$), as was oxytocin augmentation in spontaneous labour (23.3 vs 20.7%; RR 1.22, 95% CI 0.83–1.79, $P = 0.304$). Epidural analgesia usage was higher in obese than normal BMI women (44.0 vs 37.0%; RR 1.20, 95% CI 1.01–1.44, $P = 0.040$).

DISCUSSION

This analysis of 600 labouring women demonstrated a significantly higher rate of CD in women with Class III obesity, when compared to women with a normal BMI after matching for maternal age, parity, gestational age at delivery, and birth weight. The risk of CD was 43% higher in women of Class III obesity as compared with women of normal BMI. Although not statistically significant, the rates of CD were higher for both indications of failure to progress in labour and maternal/fetal concerns. When investigating the timing of CD, the mean cervical dilation at the time of delivery was lower for the Class III obese cohort, with a slower rate of cervical dilation preceding CD, as compared to the normal BMI cohort. While not statistically significant, the obese cohort had higher total dosage and rate of oxytocin infusion prior to CD, despite a similar duration of oxytocin infusion, suggesting that sufficient trial of vaginal delivery was attempted prior to the clinical decision of CD for failure to progress.

Obese women had a longer duration of labour, particularly those undergoing IOL, compared to women with normal BMI. Intrapartum intervention rates were also higher in the obese cohort, with significantly higher rates of utilisation of fetal scalp electrodes and intrauterine pressure catheters, higher rates of fetal scalp lactate sampling, and increased frequency of vaginal examinations. These findings are in keeping with the logistical challenges of intrapartum care for women with an increased BMI.

Limitations

The main strength of this study is the matching process which accounts for multiple potential confounding factors, allowing a focused exploration of the impact of BMI on labour management and outcomes. We were able to perform individual chart reviews to interrogate the events and interventions prior to decision for CD for inadequate progress, which contributes to our understanding of the timing and decision-making for the different cohorts. Furthermore, we were able to access a large cohort of Class III obese women as the health network used is a referral centre for management of pregnancies complicated by obesity. This allowed us to use a limited, three-year period from which women were selected for the matching process, reducing the influence of changes in clinical practice over a larger period of time.

Despite the matching process, the retrospective design of this study may be limited by the accuracy of record keeping and the availability of routinely collected outcomes, as well as the possibility of confounding factors that were unaccounted for or unmeasured. Fortunately, the key outcomes determined for our study were within the scope of available, routinely collected data, and a large cohort of participants was selected for the analysis. When evaluating the direct effect of BMI on labour outcomes, it is essential to control for maternal age, which may be associated with BMI as well as pregnancy complications and outcomes independently of BMI, and for other factors such as gestational age and fetal size (as rates of prolonged pregnancies and large-for-gestational age fetuses are higher among women with increased BMI). A further limitation is that all participants were selected from records of one health network, which may limit generalisability. The results demonstrated comparable rates of cervical dilation and oxytocin use; however, studies in multiple centres may demonstrate different findings around clinician impact on labour management. Future studies targeting all classes of obesity, with larger cohorts for subgroup analyses may strengthen the understanding of the clinical impact of obesity.

Interpretation and comparison with previous literature

Our finding of higher risk of CD for Class III obese women is in keeping with findings of previous, unmatched cohort studies.[11,12] Class III obesity has been associated with increased rates of failed labour induction and emergency CD for both primiparous and multiparous women[5] which, although not statistically significant, was also identified in our cohort.

The finding of increased labour duration in obese women is also consistent with findings from previous studies.[5] Specifically, it has been suggested that the prolonged labour is mainly confined to the first stage of labour, with authors recommending clinicians allow increased time to progress in the first stage of labour for obese women.[13] Our findings suggest that adequate time was given to the women who had a CD for inadequate progress. The median cervical dilation at time of caesarean was 2 cm lower in the obese cohort, also consistent with previous studies.[3] While this finding was not statistically significant (potentially due to the smaller population of this subgroup), it is consistent with a trend for obese women having a slower first stage of labour.

When considering intrapartum interventions, it has previously been identified that obesity is associated with higher rates of oxytocin use and a longer duration of oxytocin administration,[6,7] consistent with our findings. There is a paucity of evidence regarding the risk of other interventions explored in our study (terbutaline, frequency of vaginal examination, intrauterine pressure catheter, fetal scalp electrode, and fetal scalp lactate sampling); however, it has previously been identified that vaginal examinations in obese women had a higher incidence of difficulty or poor access, matching our overall impression of increased challenges with monitoring during labour.[14]

Clinical and research implications

Our study further substantiates the rationale for tertiary centre care in the setting of morbid obesity. Adequate labour ward staffing and facilities must be available in anticipation of longer and potentially more complex labour, to facilitate safe and effective care. Our findings suggest that for women with morbid obesity, an increased duration of labour induction in the absence of safety concerns, may be required to allow adequate time for a slower first stage.

By demonstrating increased use of fetal scalp electrodes, intrauterine pressure catheters, and fetal scalp lactate sampling in the obese cohort, our study adds to the body of evidence that can be used to guide shared decision-making around delivery for these women. While these interventions may be appropriate to ensure safe monitoring and assessment during labour, reasonable expectations of possible interventions during labour may assist with patient experience and satisfaction, or may guide decision-making to an elective CD, should these interventions be seen as unacceptable risks.

Our analysis contributes to the growing body of evidence exploring the increased risks associated with morbid obesity in labour. Further research should investigate whether the risks identified for labour induction in obese women could be attributed to circulating levels of oxytocin, or even if administration of higher doses improves labour outcomes. In addition, qualitative analysis of the experiences of labour management for labouring women stratified by BMI subgroups, as well as the clinicians providing care, may further enhance our understanding and contribute to improving outcomes and patient satisfaction.

Women with Class III obesity have significantly higher rates of CD and intrapartum interventions as compared to women with a normal BMI, after controlling for maternal age, parity, gestational age and fetal size. These associations are indicative of a clinically significant biological influence of obesity on labour.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1. Baseline maternal and neonatal characteristics across the study population.