ORIGINAL RESEARCH

DOI: 10.5336/jcog.2019-71902

The Effects of Gestational Weight Gain and Maternal Body Mass Index Discrepancy on All Stages of Labor

Bora ÇOŞKUN[a],
Çağrı GÜLÜMSER[b],
Emine AYDIN[c],
Buğra ÇOŞKUN[a],
Gülçin SERPİM[d],
Tuğberk GÜÇLÜ[e],
Mehmet Özgür AKKURT[f]

[a]Department of Obstetrics and Gynecology, Yüksek İhtisas University Faculty of Medicine Liv Hospital Ankara,
[b]Department of Obstetrics and Gynecology, University of Health Science Faculty of Medicine, Ankara, TURKEY
[c]Department of Obstetrics and Gynecology, İstanbul Medipol University Faculty of Medicine, İstanbul, TURKEY
[d]Clinic of Obstetrics and Gynecology, Bursa Yüksek İhtisas Training and Research Hospital, Bursa, TURKEY
[e]Clinic of Obstetrics and Gynecology, Kars Harakani State Hospital, Kars, TURKEY
[f]Clinic of Obstetrics and Gynecology, Esentepe Hospital, Bursa, TURKEY

Received: 18 Oct 2019
Received in revised form: 26 Nov 2019
Accepted: 27 Nov 2019
Available online: 02 Dec 2019

Correspondence:
Bora ÇOŞKUN
Yüksek İhtisas University Faculty of Medicine Liv Hospital Ankara, Department of Obstetrics and Gynecology Ankara, TURKEY
drboracoskun@gmail.com

ABSTRACT Objective: To investigate the effects of maternal body mass index (BMI) and total weight gain during the pregnancy (WGDP) on all stages of labor. **Material and Methods**: This is a prospective case-control study carried out at a tertiary referral hospital during 1-year period of time. We divided study population into 4 groups according to BMI and classified women according to WGDP; inadequate, optimum, excessive. Then we assessed the maternal characteristics, cesarean rate, all variables of labor stages, delivery complications, operative delivery rates, and interventions such as; induction rate and episiotomy. **Results:** A total of 523 women were included in the study [n=55 (10.5%) cesarean section and n=468 (89.5%) vaginal delivery]. There were 435 pregnant Turkish women and 88 Syrian Refugees in the study population. Younger maternal age and need for episiotomy was more common in low-weight group than others. All stages of labor except transition stages (duration between 7 and 10 cm of cervical dilatation) was longer in obese group (222.9±35.6 min, 195.8±29.6 min, 200.6±30.4 min, 255.8±38.2 min in group 1,2,3 and 4, respectively) ($p<0.05$). We found no statistically significant effect of weight gain on the duration of labor. **Conclusion:** Either low and high pre-gestational BMI are found to lead to increased risk of adverse labor results in compatible with literature. Therefore, professionals should support weight loss or gain to achieve optimal BMI in women planning pregnancy.

Keywords: Body mass index; delivery; labor; weight gain

The number of women starting pregnancy with high body mass index (BMI) (calculated as weight in kg/square of height in m^2) increases over years due to maternal age and improper diets.[1,2] The prevalence of obesity in pregnant women varies widely depending upon the population. In the USA, the prevalence of pre-pregnancy obesity and overweight is both 26%.[3]

High pre-pregnancy BMI and excessive weight gain during pregnancy confers increased risk of gestational diabetes mellitus (GDM), preeclampsia, dystocia and cesarean delivery (CD).[4,5] Although the mode of delivery is still determined by obstetric indications, it is reported that the frequency of CD increases in obese women.[5]

In this study, we aimed to evaluate the effect of pre-pregnancy BMI and weight gain during pregnancy on the mode of delivery, durations of active stage of delivery and second stage of delivery.

MATERIAL AND METHODS

The present prospective case-control study was carried out at Bursa Training and Research Hospital during 1-year period. Data were abstracted from

women who were admitted for labor. The study has been reviewed and approved by the Institutional Review Board of Bursa Yuksek Ihtisas Training and Research Hospital (Decision dated 25/07/2018 and numbered 2011-KAEK-25 2018/07-44). The study was conducted in accordance with the Helsinki Declaration. Written consents were received from all patients before the study.

Inclusion criteria were full-term singleton pregnancy, cephalic presentation, completed prenatal data with a follow-up at our center. Patients were excluded if they had chronic diseases (heart, brain, lungs, liver or renal disease), gestational diabetes mellitus, preeclampsia, placenta previa, severe fetal anomalies and stillbirth. All subjects were divided into groups according to BMI which is defined by World Health Organization (WHO) as low, normal, overweight or obesity.

Based on the WHO classification, "low" and "normal" body weights are reflected by a BMI between <18.5 kg/m^2 -18.5 kg/m^2, and BMI <24.9 kg/m^2, respectively, whereas "overweight" and "obesity" are reflected by values between 25.0 kg/m^2 - <29.9 kg/m^2, and BMI ≥30.0 kg/m^2, respectively. After this classification, same patients were sorted according to Institute of Medicine (IOM) recommendations related to patients' weight gain during the pregnancy (WGDP); as inadequate, adequate and excessive.[6]

Data including parity, nationality, maternal age, maternal height, weight before pregnancy, BMI, end of pregnancy weight, total weight, mode of delivery (cesarean delivery, vaginal delivery, operative delivery), presence of spontaneous labor, augmentation and induction need, active stage duration, second stage of delivery, placental separation time, the presence of episiotomy, the presence of laceration, gestational week at delivery, sonographic measurements of fetus (biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL), estimated fetal weight (EFW)), birth weight, fetal gender, Apgar scores at 1st and 5th minute, and CD indications were obtained from maternal and neonatal files.

Active phase of the first stage of labor started from the moment the cervical opening reached 3 cm, as described before. The active phase period was divided into 3 phases; between 4-6 cm, 6-8 cm, 8-10 cm of cervical dilatation. The decision and timing of induction, amniotomy and episiotomy in all patients was decided by the senior author (MÖA).

STATISTICAL ANALYSES

Statistical analysis for the data was performed by SPSS version 22.0 (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.). Categorical variables were calculated as percentage or frequency and continuous variables were given as mean ± standard deviation. One-way Anova test or Kruskal Wallis test was used for comparison of continuous variables. The categorical variables were compared with Pearson's chi-square test. The analysis of pairwise comparisons between groups was performed with LSD or Conover-Inman test. P value <0.05 was accepted as statistically significant in all analyzes.

RESULTS

A total of 523 women constituted the study population; 55 had cesarean section and 468 had normal vaginal delivery. Of the 468 women giving birth by vaginal route; 20, 257, 137 and 53 were in underweight, normal weight, overweight and obese group respectively. Vacuum was needed for a patient in the normal weight group.

Maternal characteristics and information related to the stages of labor are shown in Table 1 and Table 2, when groups were classified according to BMI and WGDP. According to this analysis, the duration between 4-6 cm and 6-8 cm of cervical dilatation was longer in overweight group compared with the other groups. The need for episiotomy was more frequent in low weight group (Table 1). The need of oxytocin augmentation or induction was not different among groups (Table 1). Although, excessive weight gain was found to increase the risk of CD, weight gain during pregnancy had no effect on stages of labor as shown in Table 2.

Fetal biometric measurements, gestational week at delivery, birth weights, gender and Apgar scores in terms of pre-pregnancy BMI and WGDP are presented in Table 3. Gestational weeks at de-

TABLE 1: Comparison of maternal characteristics and data regarding stages of labor among groups.

		BMI (<18) (n=23)	BMI (18-24.9) (n=289)	BMI (25-29.9) (n=152)	BMI (>30) (n=59)	p
Nationality$^{\delta}$	Syrian	-	56 (19.4%)	22 (14.5%)	10 (16.9%)	0.086
	Turkish00	23 (100%)	233 (80.6%)	130 (85.5%)	49 (83.1%)	
Parity		0.91±1.22	1.03±1.39	1.1 ±1.26	0.94 ±1.34	**0.09**
Age (year) *		22.91±3.99	25.39±5.88	27.96±5.69	29.73±6.13	**<0.001**
BMI*		16.94±1.04	21.66±1.90	26.93±1.38	32.90±3.18	**<0.001**
Total weight gain*		17.57±6.27	13.30±6.48	12.27±7.50	8.81±6.13	**<0.001**
Mode of delivery $^{\delta}$	Cesarean delivery	3 (13.0%)	31 (10.7%)	15 (9.9%)	6 (10.2%)	0.983
	Vaginal delivery	20 (87.0%)	257 (88.9%)	137 (90.1%)	53 (89.8%)	
	Vaginal delivery+Vacuum	-	1 (0.3%)	-	-	
Augmentation $^{\delta}$		13 (56.5%)	166 (57.4%)	90 (59.2%)	34 (57.6%)	0.985
Induction$^{\delta}$		7 (30.4%)	87 (30.1%)	47 (30.9%)	14 (23.7%)	0.766
4-10 cm (minute)$^{\beta}$		222.9±35.6	195.8±29.6	200.6±30.4	255.8±38.2	**0.04**
4-6 cm (minute)$^{\beta}$		141.5±22.4	120.3±19.2	120.5±20.6	150.1±23.2	**0.03**
6-8 cm (minute)$^{\beta}$		66.3±9.2	55.2±8.2	60.1±9.5	85.3±12.3	**0.019**
8-10 cm (minute)$^{\beta}$		15.1±3.1	20.3±5.1	20±4.6	20.4±4.5	0.667
Full Open (minute)$^{\beta}$		15.2±3.3	10.9±2.6	10±2.6	13±2.8	0.07
Need for episiotomy$^{\delta}$		18 (78.3%)	171 (59.2%)	76 (50.0%)	22 (37.3%)	**<0.001**
Laceration$^{\delta}$		-	5 (1.7%)	1 (0.7%)	3 (5.1%)	0.147
Biparietal diameter (BPD) (mm) *		91.7±3.6	90.8±4.3	90.9±4.3	90.3±3.9	0.320
Femur length (FL) (mm) *		72.6±3.4	73.6±3.8	73.5±3.5	73.3±3.7	0.219
Abdominal circumference (AC) (mm) *		341.0±16.2	368.6±291.9	360.7±232.9	390.3±371.2	0.876
Delivery weight (g) *		3302±480	3186±495	3295±464	3363±463	**0.020**
Gender (Male %)		15 (65.2%)	145 (50.2%)	80 (52.6%)	29(49.2%)	0.54
Head Circumference* (mm)		345±15.9	343±13.5	344± 29	345±13.3	0.79
Apgar 1*		8.9±0.2	8.9±0.2	8.9±0.3	8.8± 0.6	0.48
Apgar 5*		9.8±0.4	9.9±0.2	9.9±0.3	9.8±0.6	0.35
Gestational Week*		36.8±7.3	38.6±1.6	39±1.8	38.6±1.7	**0.002**

Continuous variables are expressed as either * the mean±standard deviation (SD) and categorical variables are expressed as either $^{\delta}$ frequency or percentage. $^{\beta}$ Continuous variables were compared with an one way anova test or the Kruskal wallis test, and categorical variables were compared using Pearson's chi-square test. LSD or Conover-Inman test were performed for the binary comparisons among the groups and the p value was set at 0.05.

TABLE 2: Comparison of maternal characteristics and delivery results among groups in terms of weight gain during pregnancy.

		Inadequate (n=160)	Adequate (n=151)	Excessive (n=212)	p
Nationality δ	Syrian	41 (25.6%)	15 (9.9%)	32 (15.1%)	**0.001**
	Turkish	119 (74.4%)	136 (90.1%)	180 (84.9%)	
Parity		1.06±1.34	1.12±1.31	0.95±1.36	**0.08**
Age (year) *		26.3±6.5	26.68±5.95	26.6±5.6	0.86
Size (cm) *		1.6±0.6	1.6±0.5	1.6±0.6	0.65
BMI*		24.0±4.1	24.0±4.7	24.5±4.6	0.39
Total weight*		5.7±3.9	11.5±2.8	18.7±5.2	**<0.001**
Mode of delivery δ	Cesarean delivery	11 (6.9%)	11 (7.3%)	33 (15.6%)	**0.018**
	Vaginal delivery	148 (92.5%)	140 (92.7%)	179 (84.4%)	
	Vaginal delivery+vacuum	1 (0.6%)	-	-	
Spontaneous pain δ		126 (78.8%)	93 (61.6%)	150 (70.8%)	**0.004**
Augmentation δ		98 (61.3%)	80 (53.0%)	125 (59%)	0.31
Induction δ		35 (21.9%)	58 (38.4%)	62 (29.2%)	**0.006**
4-10 cm (min) β		217±32.3	206±30.4	225±33.3	0.33
4-6 cm (min) β		137.5±18.4	135.5±15.6	142.2±20.1	0.09
6-8 cm (min) β		62±10.2	51.4±8.6	62.5±9.7	0.86
8-10 cm (min) β		17.5±3.5	18.1±4.0	20 .3±3.6	0.14
Full dilatation (min) β		10	10	10	0.65
Duration for placental separation (min) β					0.07
Need for episiotomy δ		93 (58.1%)	86 (57.0%)	108 (50.9%)	0.32
Laceration δ		1 (0.6%)	3 (2.0%)	5 (2.4%)	0.42
Biparietal diameter (BPD) (mm)*		90.5±4.6	90.3±4.1	91.4±3.8	**0.015**
Femur length (FL) (mm) *		73.0±3.3	73.3±3.7	73.8±3.36	0.08
Abdominal circumference (AC) (mm) *		411.7±450.0	338.0±19.4	355.8±197.4	0.06
Delivery weight (g) *		3188.1±443.6	3227.5±482.6	3295.9±513.6	0.09
Gender (Male %) δ		88 (55.0%)	85 (56.3%)	96 (45.3%)	0.06
Head circumference*		34.3±1.3	34.3±1.3	34.4±2.5	0.87
Apgar 1*		8.9±0.2	8.9±0.2	8.9±0.4	0.20
Apgar 5*		9.9±0.2	9.9±0.2	9.8±0.4	0.23
Gestational Week*		38.5±1.7	38.7±1.8	38.5±2.9	0.60

Continuous variables are expressed as either * the mean±standard deviation (SD) and categorical variables are expressed as either δ frequency or percentage. β Continuous variables were compared with an one way anova test or the Kruskal wallis test, and categorical variables were compared using Pearson's chi-square test. LSD or Conover-Inman test were performed for the binary comparisons among the groups and the p value was set at 0.05.

TABLE 3: Effect of head circumference and BMI on active phases of labor.

		Univariate linear regression analysis			
		Standardized coefficients		95% CI for B	
Dependent Variable		Beta	Lower bound	Upper bound	p
4-10 cm (minute)	BMI	-0.087	-5.517	0.097	0.058
	Head circumference	0.107	1.797	20.121	**0.019**
4-6 cm (minute)	BMI	-0.015	-2.279	1.631	0.745
	Head circumference	0.073	-0.764	8.343	0.103
6-8 cm (minute)	BMI	-0.184	-4.181	-1.430	**<0.001**
	Head circumference	0.080	-0.342	5.812	0.081
8-10 cm (minute)	BMI	-0.071	-1.585	0.272	0.165
	Head circumference	0.134	0.958	6.857	**0.010**
Full Open (minute)	BMI	-0.087	-0.820	0.024	0.064
	Head circumference	0.100	0.105	2.910	**0.035**

Dependent Variable: 4-10 cm, 4-6 cm, 6-8 cm, 8-10 cm and full open. Independent Variables: BMI (body mass index) and Head Circumference. CI (95%); confidence interval.

livery differed between underweight, normal weight, overweight and obese patients (p= 0.002) (Table 1).

A statistically significant difference was found between birth weights in normal weight, overweight and obese groups (p= 0.02) but there was no statistically significant difference between these groups according to WGDP (Table 2).

There were no effects of only BMI or only HC on the delivery mode (cesarean delivery or vaginal delivery) (p= 0.453 and p= 0.586, respectively). But as regards the details, HC effects durations of active stage and second stage of labor. Duration of cervical dilatation between 8-10 cm, total active stage duration (4-10 cm) and the duration of second stage were influenced by HC (Table 3).

DISCUSSION

The adverse effects of high BMI before pregnancy and excessive WGDP and delivery process have been investigated repeatedly.[4-7] Low or high BMI has adverse effects on pregnancy outcomes and infant's health. The risk of large-for-gestational-age births (LGA), cesarean delivery and childhood obesity are increased in overweight women (BMI 25.0-29.9 kg/m^2) and maternal obesity (BMI ≥30.0 kg/m^2). However small-for-gestational-age (SGA) births are frequently seen in the pre-pregnancy underweight (BMI <18) women.[8] In previous studies, the authors reported that high BMI is associated with elevated CD rates associated with relative obstruction of birth canal due to expanding pelvic tissue.[5,8-10] In another study, researchers claimed that women who are overweight or obese may experience increased risk of cesarean delivery as a consequence of excess pelvic soft tissue, which can lead to a relative obstruction of the birth canal.[11] In addition, decreased cervical dilatation rates leading to increased inductions among obese women also increases cesarean delivery risk.[12] Our cesarean delivery ratio was 10.5%, and pre-pregnancy BMI was not effective on mode of delivery, but we observed an increase in cesarean delivery patients with excessive WGDP (p=0.018). Similarly, the presence of spontaneous pain and the need for induction were more frequent in patients with excessive weight gain. Induction rates and induction failure show an increase despite the spontaneous pain in women with excessive WGDP.

Most previous studies reported that BMI has independent effect on duration of active labor.[12-17] According to these studies, duration of first-stage of labor expands although furthers support overall duration of labor expands.[12-17] Similarly, a previous study claimed a statically significant increase in total labor duration in obese nulliparous.[13] However, this study differed from

the others by the inclusion of patients from 1 cm cervical opening, which is evaluated as latent stage. Another study which involves 63,829 nulliparous women showed slower progression of labor in women who had high BMI than normal BMI.[12] In our study, we evaluated labor progression, active stage and second stage of labor according to both pre-pregnancy BMI and WGDP. The duration of cervical opening from 6 cm to 8 cm in the active phase and the duration of the second stage of labor (cervix fully open) were significantly different between pre-pregnancy underweight (BMI<18 kg/m^2) and overweight (BMI: 25-29,9 kg/m^2) groups. No significant changes were observed in the total period of active stage (cervical opening 4-10 cm) and labor durations according to WGDP during pregnancy.

In the second stage of labor, the patient's pushing force is also effective, so it is arguable how accurate it is to reconcile with WGDP during pregnancy. However, this situation is considered to be controversial in other studies too.[5] In our study this time was significantly different between the two groups in terms of BMI<18 and BMI between 25 -30 kg/m^2. Moreover, we did not use epidural analgesia which can affect the labor time in any patient.

Furthermore, the risk of congenital anomalies such as cardiac anomalies, facial defects and extremity abnormalities are increased in obese women.[18] Maternal obesity and excessive WGDP also increase antepartum and postpartum complication risk including fetal death, stillbirth, birth asphyxia, prematurity, LGA and shoulder dystocia.[19-21] In this respect, we found statistically significant differences in birthweight and gestational week at delivery between BMI 18-24,9 kg/m^2 vs BMI 25-29,9 kg/m^2 and BMI 18-24,9 kg/m^2 vs BMI >30 kg/m^2 groups. Beside these findings, we have no other significant outcome about neonates.

Prolonged second stage of labor was detected when head circumference was above the 75th percentile. It might be associated with neonatal asphyxia due to increased obstetric interventions.[22] However, in our study, we did not find any effect of HC on duration between 8 and 10 cm of cervical dilatation, second stage of labor and total time of active stage.

The limitation of our study is the small number of patients in the study group. Moreover, study population is unequally distributed among groups. Therefore, results may preclude precise conclusions. Precise results can be achieved with larger study groups.

CONCLUSION

In conclusion, both low and high pre-pregnancy BMI are associated with increased risk of operative delivery and prolonged active stages of labor. Therefore, we think that pre-pregnancy weight control is very important.

Informing

Due to the presence of the name of the journal editor's among the authors, the assessment process of the study was conducted by the guest editor.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Bora Çoşkun, Mehmet Özgür Akkurt, Çağrı Gülümser;* ***Design:*** *Bora Çoşkun, Mehmet Özgür Akkurt, Buğra Çoşkun;* ***Control/Supervision:*** *Çağrı Gülümser, Mehmet Özgür Akkurt;* ***Data Collection and/or Processing:*** *Tuğberk Güçlü, Gülçin Serpim, Buğra Çoşkun;* ***Analysis and/or Interpretation:*** *Bora Çoşkun, Emine Aydin, Çağrı Gülümser;* ***Literature Review:*** *Bora Çoşkun, Emine Aydin;* ***Writing the Article:*** *Bora Çoşkun, Çağrı Gülümser, Emine Aydin;* ***Critical Review:*** *Buğra Çoşkun, Çağrı Gülümser;* ***References and Fundings:*** *Bora Çoşkun, Mehmet Özgür Akkurt;* ***Materials:*** *Tuğberk Güçlü, Gülçin Serpim.*

REFERENCES

1. Fisher SC, Kim SY, Sharma AJ, Rochat R, Morrow B. Is obesity still increasing among pregnant women? Prepregnancy obesity trends in 20 states, 2003-2009. Prev Med. 2013;56(6):372-8. [Crossref] [PubMed] [PMC]
2. World Health Organization (WHO). Global Health Observatory Data Repository. Accessed 6 Nov 2014. [Crossref]
3. Deputy NP, Dub B, Sharma AJ. Prevalence and trends in prepregnancy normal weight-48 States, New York City, and District of Columbia, 2011-2015. MMWR Morb Mortal Wkly Rep. 2018;66(5152):1402-7. [Crossref] [PubMed] [PMC]
4. Cedergren MI. Maternal morbid obesity and the risk of adverse pregnancy outcome. Obstet Gynecol. 2004;103(2):219-24. [Crossref] [PubMed]
5. Ellekjaer KL, Bergholt T, Løkkegaard E. Maternal obesity and its effect on labour duration in nulliparous women: a retrospective observational cohort study. BMC Pregnancy Childbirth. 2017;17(1):222. [Crossref] [PubMed] [PMC]
6. Institute of Medicine, Committee on Nutritional Status During Pregnancy and Lactation. Nutrition During Pregnancy: Part I, Weight Gain: Part II, Nutrient Supplements. 1st ed. Washington, D.C: National Academy Press; 1990. p.480.
7. Maged AM, Belal DS, Marie HM, Rashwan H, Abdelaziz S, Gabr AA, et al. Prospective study of the effect of maternal body mass index on labor progress in nulliparous women in Egypt. Int J Gynecol Obstet. 2017;139(3):329-35. [Crossref] [PubMed]
8. Liu P, Xu L, Wang Y, Zhang Y, Du Y, Sun Y, et al. Association between perinatal outcomes and maternal pre-pregnancy body mass index. Obes Rev. 2016;17(11):1091-102. [Crossref] [PubMed]
9. Davies GAL, Maxwell C, McLeod L. Obesity in pregnancy. J Obstet Gynaecol Can. 2010;32(2):165-73. [PubMed]
10. Bergholt T, Lim LK, Jørgensen JS, Robson MS. Maternal body mass index in the first trimester and risk of caesarean delivery in nulliparous women in spontaneous labour. Am J Obstet Gynecol. 2007;196(2):163.e1-5. [Crossref] [PubMed]
11. Usha Kiran TS, Hemmadi S, Bethel J, Evans J. Outcome of pregnancy in a woman with an increased body mass index. BJOG. 2005;112(6):768-72. [Crossref] [PubMed]
12. Carlhäll S, Källén K, Blomberg M. Maternal body mass index and duration of labor. Eur J Obstet Gynecol Reprod Biol. 2013;171(1):49-53. [Crossref] [PubMed]
13. Norman SM, Tuuli MG, Odibo AO, Caughey AB, Roehl KA, Cahill AG. The effects of obesity on the first stage of labour. Obstet Gynecol. 2012;120(1):130-5. [Crossref] [PubMed] [PMC]
14. Kominiarek MA, Zhang J, Vanveldhuisen P, Troendle J, Beaver J, Hibbard JU. Contemporary labor patterns: the impact of maternal body mass index. Am J Obstet Gynecol. 2011;205(3):244.e1-8. [Crossref] [PubMed] [PMC]
15. Vahratian A, Zhang J, Troendle JF, Savitz DA, Siega-Riz AM. Maternal prepregnancy overweight and obesity and the pattern of labor progression in term nulliparous women. Obstet Gynecol. 2004;104(5 Pt 1):943-51. [Crossref] [PubMed]
16. Hilliard AM, Chauhan SP, Zhao Y, Rankins NC. Effect of obesity on length of labor in nulliparous women. Am J Perinatol. 2012;29(02):127-32. [Crossref] [PubMed]
17. Pevzner L, Powers BL, Rayburn WF, Rumney P, Wing DA. Effects of maternal obesity on duration and outcomes of prostaglandin cervical ripening and labor induction. Obstet Gynecol. 2009;114(6):1315-21. [Crossref] [PubMed]
18. Stothard KJ, Tennant PW, Bell R, Rankin J. Maternal overweight and obesity and the risk of congenital anomalies: a systematic review and meta-analysis. JAMA. 2009;301(6):636-50. [Crossref] [PubMed]
19. Persson M, Johansson S, Villamor E, Cnattingius S. Maternal overweight and obesity and risks of severe birth-asphyxia-related complications in term infants: a population-based cohort study in Sweden. PLoS Med. 2014;11(5):e1001648. [Crossref] [PubMed] [PMC]
20. 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. JAMA. 2014;311(15):1536-46. [Crossref] [PubMed]
21. Lu GC, Rouse DJ, DuBard M, Cliver S, Kimberlin D, Hauth JC. The effect of the increasing prevalence of maternal obesity on perinatal morbidity. Am J Obstet Gynecol. 2001;185(4):845-9. [Crossref] [PubMed]
22. Aviram A, Yogev Y, Bardin R, Hiersch L, Wiznitzer A, Hadar E. Association between sonographic measurement of fetal head circumference and labor outcome. Int J Gynecol Obstet. 2016;132(1):72-6. [Crossref] [PubMed]