

Original Research Article

Effect of Each Trimester Weight Gain in Pregnancy on Maternal Hemodynamics during Elective Cesarean Section after Subarachnoid Blockade

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ABSTRACT

Background: Pregnancy is associated with significant physiological and haemodynamic changes, and spinal anaesthesia may produce a greater fall in blood pressure because of sympathetic blockade. Maternal weight gain during pregnancy may influence haemodynamic responses to subarachnoid blockade. This study evaluated the effect of weight gain during each trimester on maternal heart rate changes and spinal-induced hypotension during elective caesarean section.

Methods: This observational cross-sectional study was conducted in a Tertiary Care Centre, South India for a period of 22 months. Ninety-three healthy singleton term parturients aged 18-35 years with normal pre-pregnancy BMI and ASA II status were included and divided into three groups according to total pregnancy weight gain: Group A (8-10 kg), Group B (11-13 kg), and Group C (>13 kg), with 31 participants in each group. Standardized spinal anaesthesia with 2 mL of 0.5% hyperbaric bupivacaine was administered. Heart rate and blood pressure were recorded immediately after spinal anaesthesia and every 5 minutes for 45 minutes.

Results: Mean total weight gain was 9 kg, 11.74 kg and 14.44 kg in Groups A, B and C, respectively. Baseline heart rate did not differ significantly among groups. Baseline systolic blood pressure was significantly lower in Group A. The frequency of hypotension was significantly higher in Group A than Group C ($p=0.044$), with a greater mephentermine requirement in Group A (7.55 mg vs 4.84 mg and 3.10 mg; $p=0.015$). However, weight gain in individual trimesters was not significantly associated with hypotension or heart-rate changes. Newborn birth weight was significantly lower in Group A (2.81 kg) than Groups B (2.99 kg) and C (3.26 kg). APGAR scores were comparable.

Conclusion: Inadequate maternal weight gain, particularly below 11 kg, was associated with lower baseline systolic blood pressure, increased incidence of hypotension following subarachnoid blockade, greater vasopressor requirement and lower neonatal birth weight. However, individual trimester weight gain was not associated with haemodynamic changes.

Keywords: Pregnancy, Maternal Weight Gain, Spinal Anaesthesia, Subarachnoid Blockade, Hypotension, Haemodynamics, Caesarean Section.

INTRODUCTION

Pregnancy is associated with profound anatomical and physiological adaptations that support fetal growth and prepare the mother for parturition. These changes involve almost every organ system and have important implications for anaesthetic management. During pregnancy, there is increased dependence on the sympathetic nervous system for maintenance of haemodynamic

stability, which reaches its peak near term. Consequently, pharmacological sympathectomy produced by regional anaesthesia may result in a greater fall in blood pressure in pregnant women compared with non-pregnant individuals.^[1] Maternal body weight also increases progressively during pregnancy, and an understanding of these physiological adaptations is essential for appropriate modification of anaesthetic techniques and

ensuring safe maternal and fetal outcomes during surgical procedures, labor analgesia, and caesarean delivery.

Regional anaesthesia, particularly spinal and epidural anaesthesia, is preferred over general anaesthesia for most caesarean sections because it avoids the risks associated with difficult or failed tracheal intubation, aspiration of gastric contents, and potential maternal and fetal complications associated with general anaesthesia.^[2] Spinal anaesthesia has become widely used following the introduction of small-gauge pencil-point needles, which substantially reduced the incidence of post-dural puncture headache. It offers several advantages, including rapid administration, cost-effectiveness, satisfactory maternal comfort, reduced requirement for additional intraoperative analgesics, and shorter post-anaesthesia care unit stay compared with epidural anaesthesia. However, in women receiving labour analgesia who subsequently require caesarean delivery, an in-situ epidural catheter can be utilized to provide surgical anaesthesia.^[3]

Maternal nutritional status and appropriate gestational weight gain are also important determinants of maternal and fetal outcomes. Maintaining a normal body mass index before conception and achieving adequate weight gain during pregnancy according to established recommendations are advisable.^[4,5] Inadequate gestational weight gain (<11 kg) in singleton pregnancies has been associated with increased heart rate variability and a higher incidence of spinal anaesthesia-induced hypotension during elective caesarean section.^[6]

Heart rate variability, which represents beat-to-beat variation in cardiac rhythm, reflects the dynamic interaction between the sympathetic and parasympathetic components of the autonomic nervous system. HRV (Heart Rate Variability) analysis has been extensively studied in pregnant and non-pregnant women as a non-invasive method of assessing autonomic function. Importantly, HRV parameters have been investigated for their potential role in identifying parturients who are at increased risk of hypotension following spinal anaesthesia.^[7]

AIMS AND OBJECTIVES

The present study aims to evaluate the effect of weight gain during each trimester of pregnancy on maternal heart rate changes and the incidence and severity of spinal-induced hypotension following subarachnoid blockade in

singleton term parturients undergoing elective caesarean section. The study also aims to assess whether trimester-wise maternal weight gain influences maternal haemodynamic parameters following subarachnoid blockade and to identify other independent maternal or obstetric variables that may influence maternal haemodynamics and fetal outcomes.

MATERIALS AND METHODS

Study Design

This observational cross-sectional study was conducted in the Department of Anaesthesiology in a Tertiary Care Centre, South India over a period of 22 months.

Inclusion and Exclusion Criteria

The study included patients aged 18–35 years who provided informed consent to participate, had a normal pre-pregnancy BMI (Body Mass Index) of 18–25 kg/m², were classified as ASA physical status II, and had a normal singleton term pregnancy without known fetal abnormalities. Patients were excluded if they refused to participate, had contraindications to spinal anaesthesia, placenta praevia or placenta accreta, pregnancy-induced hypertension, pre-eclampsia or gestational diabetes, anaemia, coagulopathy or cardiovascular disease, spinal cord abnormalities, a history of spinal surgery, or pre-existing neurological deficits. Patients with a pre-pregnancy BMI below 18 kg/m² or above 25 kg/m² were also excluded.

Sample Size Calculation

The sample size required was calculated to be 31 in each group with power of study 80% and confidence interval of 95%. Based on weight gain during pregnancy, study population is divided into 3 groups:

Group A: 8-10 kg total weight gain

Group B: 11-13 kg total weight gain

Group C: >13 kg total weight gain

Data Collection Procedure

After obtaining Institutional Ethics Committee approval and written informed consent, 93 eligible parturients were enrolled after applying the predefined inclusion and exclusion criteria. On the day before elective caesarean section, each patient was weighed using the same weighing scale and categorized into three groups according to total pregnancy weight gain: 8–10 kg, 11–13 kg, and >13 kg. Weight gain during each trimester was recorded from antenatal records. Standardized preoperative preparation and anaesthetic management were followed for all patients. Baseline heart rate and

blood pressure were recorded, followed by standard intraoperative monitoring and administration of spinal anaesthesia using 0.5% hyperbaric bupivacaine at the L3–L4 interspace. Sensory block level was assessed, and heart rate and blood pressure were recorded immediately after spinal anaesthesia and every 5 minutes for 45 minutes. Episodes of hypotension and bradycardia, along with the requirement for mephentermine and atropine, were documented. Following delivery, neonatal APGAR scores at 1 and 5 minutes, birth weight, and intraoperative blood loss were recorded. Maternal demographic, obstetric, weight-related, haemodynamic, anaesthetic, and neonatal parameters were documented in a structured proforma and subsequently entered into a master chart for analysis.

Statistical Analysis

Statistical analysis was performed using SPSS version 17.0. The association between trimester-wise maternal weight gain and

haemodynamic changes, including heart rate and spinal anaesthesia-induced hypotension, was assessed among the three study groups. One-way analysis of variance (ANOVA) with Bonferroni post-hoc test was used for comparison of continuous variables, while the chi-square test was used for categorical variables. The Karl–Pearson correlation coefficient was applied to assess the correlation between antenatal weight gain and haemodynamic changes. A p-value of <0.05 was considered statistically significant, while a p-value of <0.01 was considered highly statistically significant.

RESULTS

Table 1 illustrates the demographic characteristics of the three study groups. The mean age, pre-pregnancy weight, height and pre-pregnancy BMI were comparable among Groups A, B and C, with no statistically significant difference for any of these variables ($p > 0.05$).

Parameter	Group A (n=31)	Group B (n=31)	Group C (n=31)	p value
Age (years), Mean $\pm$ SD	28.58 $\pm$ 3.94	28.87 $\pm$ 3.84	27.39 $\pm$ 3.67	0.273
Pre-pregnancy weight (kg), Mean $\pm$ SD	47.13 $\pm$ 7.05	48.52 $\pm$ 8.50	50.47 $\pm$ 7.55	0.237
Height (cm), Mean $\pm$ SD	151.61 $\pm$ 6.05	151.42 $\pm$ 5.94	154.77 $\pm$ 6.17	0.550
Pre-pregnancy BMI (kg/m ²), Mean $\pm$ SD	20.45 $\pm$ 2.41	21.00 $\pm$ 2.28	20.97 $\pm$ 2.07	0.564

Table 1. Demographic Profile of Patients

Table 2 observes the distribution of gravida and gestational age among the three groups. Gravida distribution differed significantly,

particularly between Groups A and C, whereas gestational-age distribution was comparable among all three groups.

Parameter	Group A	Group B	Group C	Total	Statistical Finding
Primigravida, n (%)	0 (0%)	1 (3.2%)	10 (32.3%)	11 (11.8%)	A vs C: $p=0.001$
Multigravida, n (%)	31 (100%)	30 (96.8%)	21 (67.7%)	82 (88.2%)	A vs C: $p=0.001$
Gestation <38 weeks, n(%)	9 (29.0%)	12 (38.7%)	9 (29.0%)	30 (32.3%)	$p=0.646$
Gestation $\geq$ 38 weeks, n(%)	22 (71.0%)	19 (61.3%)	22 (71.0%)	63 (67.7%)	$p=0.646$

Table 2. Obstetric Profile of the Study Groups

Table 3 illustrates maternal weight at delivery, BMI at delivery and weight gain during each trimester. Increasing weight gain was observed from Group A to Group C. The differences in

delivery weight and trimester-specific weight gain were statistically significant, while the original source does not provide a p-value for total weight gain as a separate variable.

Parameter	Group A Mean $\pm$ SD	Group B Mean $\pm$ SD	Group C Mean $\pm$ SD	p value
Weight at delivery (kg)	56.13 $\pm$ 7.24	60.26 $\pm$ 8.71	64.90 $\pm$ 7.74	0.000
BMI at delivery (kg/m ²)	24.39 $\pm$ 2.54	26.14 $\pm$ 2.08	27.02 $\pm$ 2.02	0.000
Total weight gain (kg)	9.00 $\pm$ 0.86	11.74 $\pm$ 0.77	14.44 $\pm$ 0.69	Not stated
1st trimester weight gain (kg)	1.18 $\pm$ 0.74	1.42 $\pm$ 0.76	1.92 $\pm$ 1.03	0.004
2nd trimester weight gain (kg)	3.78 $\pm$ 0.91	4.84 $\pm$ 1.00	6.19 $\pm$ 0.87	0.000
3rd trimester weight gain (kg)	4.03 $\pm$ 0.83	5.48 $\pm$ 0.85	6.32 $\pm$ 1.14	0.000

Table 3. Maternal Weight and Antenatal Weight Gain

Table 4 summarizes delivery-to-neonatal and operative outcomes. Spinal-to-delivery time, APGAR scores and approximate blood loss were

comparable among the three groups. Birth weight differed significantly among the groups, with the highest mean birth weight in Group C.

Outcome	Group A Mean $\pm$ SD	Group B Mean $\pm$ SD	Group C Mean $\pm$ SD	p value
Spinal-to-delivery time (min)	11.68 $\pm$ 4.25	10.84 $\pm$ 4.16	12.60 $\pm$ 3.60	0.202
APGAR at 1st minute	9.00 $\pm$ 0.00	8.81 $\pm$ 0.91	9.00 $\pm$ 0.00	0.251
APGAR at 5th minute	9.00 $\pm$ 0.00	9.00 $\pm$ 0.00	9.00 $\pm$ 0.00	1.000
Birth weight of newborn (kg)	2.81 $\pm$ 0.29	2.99 $\pm$ 0.31	3.26 $\pm$ 0.37	0.000
Approximate blood loss (ml)	577.10 $\pm$ 57.69	574.52 $\pm$ 65.26	605.16 $\pm$ 60.33	0.097
Table 4. Delivery, Neonatal and Surgical Outcomes				

Table 5 observes the haemodynamic profile of the three groups. Baseline heart rate and lowest recorded diastolic blood pressure were comparable. Significant differences were

reported for baseline systolic blood pressure, frequency of hypotension and lowest recorded systolic blood pressure.

Haemodynamic Parameter	Group A Mean $\pm$ SD	Group B Mean $\pm$ SD	Group C Mean $\pm$ SD	p value
Baseline SBP (mm Hg)	111.10 $\pm$ 11.01	116.03 $\pm$ 7.58	117.68 $\pm$ 7.48	0.012
Baseline heart rate (beats/min)	88.77 $\pm$ 10.75	90.05 $\pm$ 12.76	88.37 $\pm$ 9.98	0.828
Frequency of hypotension	1.00 $\pm$ 0.77	0.84 $\pm$ 1.00	0.48 $\pm$ 0.63	0.044
Lowest recorded SBP (mm Hg)	79.29 $\pm$ 11.78	85.58 $\pm$ 14.28	89.19 $\pm$ 10.39	0.007
Lowest recorded DBP (mm Hg)	47.16 $\pm$ 8.13	52.52 $\pm$ 10.93	51.74 $\pm$ 10.34	0.075
Table 5. Haemodynamic Parameters				

Table 6 illustrates intraoperative drug requirements. Mean mephentermine requirement differed significantly among the groups, with Group A requiring the highest

mean dose. The atropine requirement was comparable among the three groups; only one patient in Group A required atropine.

Parameter	Group A	Group B	Group C	Total	Statistical Finding
Mephentermine required (mg), Mean $\pm$ SD	7.55 $\pm$ 6.57	4.84 $\pm$ 6.65	3.10 $\pm$ 4.35	—	Overall p=0.015
Mephentermine pairwise findings	A vs B: p=0.023	A vs C: p=0.012	B vs C: p=0.756	—	ANOVA + Bonferroni
Atropine required – No, n (%)	30 (96.8%)	31 (100%)	31 (100%)	92 (98.9%)	No significant difference stated
Atropine required – Yes, n (%)	1 (3.2%)	0 (0%)	0 (0%)	1 (1.1%)	Chi-square; p not stated
Table 6. Intraoperative Vasopressor and Atropine Requirement					

Table 7 summarizes the correlation analysis using the Karl–Pearson correlation coefficient. The source reports that frequency of hypotension was related to total antenatal weight gain, with a significant difference between Groups A and C (p=0.048). No

significant difference was reported between Groups A and B or B and C. Weight gain in individual trimesters was not significantly correlated with frequency of hypotension across the three groups (p>0.05).

Correlation/Comparison	Finding reported in the source	p value
Total antenatal weight gain vs frequency of hypotension	Significant difference reported between Groups A and C	0.048
Total antenatal weight gain – Group A vs Group B	No significant difference	>0.05
Total antenatal weight gain – Group B vs Group C	No significant difference	>0.05

1st trimester weight gain vs frequency of hypotension	No significant correlation reported	>0.05
2nd trimester weight gain vs frequency of hypotension	No significant correlation reported	>0.05
3rd trimester weight gain vs frequency of hypotension	No significant correlation reported	>0.05
Table 7. Correlation of Antenatal Weight Gain with Haemodynamic Changes		

DISCUSSION

The present study demonstrated that overall weight gain during pregnancy was associated with haemodynamic changes following subarachnoid blockade. Parturients with inadequate overall weight gain (Group A) had a higher incidence of hypotension following subarachnoid blockade compared with those in the higher weight gain categories (Groups B and C). However, weight gain during individual trimesters was not significantly associated with the incidence of hypotension or changes in heart rate in any of the three groups.

HRV is influenced by several physiological and environmental factors, including age, gender, circadian rhythm, blood pressure, respiration, temperature, endocrine factors, smoking, and cardioactive drugs. HRV and weight indices have been shown to have a significant correlation. Increased fat content has been associated with lower LF heart rate variability, which predominantly reflects sympathetic nervous system activity.^[6] Thus, alterations in maternal weight during pregnancy may influence autonomic balance and consequently affect the haemodynamic response to subarachnoid blockade.

During pregnancy, women are expected to gain approximately 17% of their pre-pregnancy weight. This increase in weight is attributable to enlargement of the uterus and its contents, increased blood volume and interstitial fluid, and deposition of fat and new protein. The uterus and its contents contribute approximately 1 kg and 5 kg, respectively, while increased blood volume and interstitial fluid contribute approximately 2 kg each, with deposition of fat and new protein accounting for approximately 4 kg.^[1] Pregnant women generally gain 1–2 kg during the first trimester and approximately 5–6 kg during each of the subsequent two trimesters.^[1] Weight gain has also been associated with alterations in noradrenaline secretion and heart rate variability, suggesting increased sympathetic activity and decreased parasympathetic activity, as demonstrated by Karason et al. in the non-pregnant state.^[8]

Hanss et al.^[9] studied pregnant patients undergoing caesarean section under spinal anaesthesia and demonstrated that measurement of baseline HRV before

subarachnoid block could identify parturients at risk of spinal-induced hypotension. They reported that an increase in HRV before subarachnoid block was a good predictor of subsequent hypotension.^[9] They also observed a decrease in HRV from baseline once hypotension developed.^[10] Similarly, Chamchad et al.^[7,11] demonstrated in pregnant women that increased baseline HRV could successfully predict hypotension following subarachnoid block during caesarean section. These findings suggest that autonomic nervous system activity, as reflected by HRV, may play an important role in determining the haemodynamic response to spinal anaesthesia. Michael A. Frolich and Donald Caton^[12] (2002) conducted a study to determine whether baseline heart rate could predict hypotension in prehydrated obstetric patients following spinal anaesthesia. They observed a significant correlation between ephedrine requirements and baseline maternal heart rate. Patients with a baseline heart rate >90 beats/min had an 83% chance, representing the positive predictive value, of developing marked hypotension following subarachnoid anaesthesia, whereas patients with a heart rate <90 beats/min had a 75% chance, representing the negative predictive value, of not developing marked hypotension. They concluded that a higher baseline heart rate may reflect increased sympathetic tone and could therefore be useful in predicting post-spinal hypotension.^[12]

In contrast to the findings of Michael A. Frolich and Donald Caton,^[12] our study did not demonstrate a significant difference in baseline heart rate among the three groups. The mean baseline heart rate was ≤90 beats/min in all three groups. In our study, baseline heart rate was determined by taking the average of two readings in the supine position. In comparison, Michael A. Frolich and Donald Caton obtained baseline heart rate and blood pressure by averaging five independent readings with the patient in the lateral decubitus position.^[12] The difference in methodology and patient positioning may have contributed to the differences observed between the two studies. Ghabach MB et al.^[6] conducted a study in pregnant women with normal pre-pregnancy BMI to evaluate the effect of weight gain during pregnancy on HRV and hypotension during

caesarean section under spinal anaesthesia. Their study demonstrated that inadequate weight gain during pregnancy (<11 kg) was associated with increased HRV and a higher incidence of spinal-induced hypotension during elective caesarean section compared with women who gained more than 11 kg. Parturients who gained <11 kg had higher baseline HRV and a higher incidence of hypotension compared with women who gained >16 kg, in whom HRV was decreased and episodes of hypotension were less frequent. The mean (SD) baseline systolic blood pressure was similar among the three groups.^[6]

The findings of Ghabach MB et al.^[6] are broadly consistent with the observations in our study. We also observed a greater incidence of hypotension among parturients with inadequate overall pregnancy weight gain. In our study, the incidence of hypotension was increased among parturients with weight gain between 8 and 10 kg compared with those who gained >13 kg. The requirement for mephentermine for treatment of hypotension was also increased in the lower weight gain category. However, unlike the findings related to overall pregnancy weight gain, weight gain during individual trimesters was not associated with the incidence of hypotension or other haemodynamic changes.

In the present study, the effect of potential haemodynamic confounding factors was also considered. Since severe blood loss can produce significant haemodynamic alterations, approximate blood loss during caesarean section was assessed. Blood loss was comparable among all three groups, suggesting that differences in blood loss were unlikely to account for the differences in hypotension observed between the weight gain categories. Although HRV would have provided a more direct assessment of autonomic changes, Holter monitoring was not exclusively available for the purpose of this study. Therefore, baseline heart rate and heart rate at 5-minute intervals following subarachnoid blockade were monitored, along with the incidence of hypotension. The collected data were statistically analysed. The three groups were comparable with respect to demographic variables, including age, pre-pregnancy weight, height, and pre-pregnancy BMI. However, significant differences in weight gain during each trimester were observed among all three groups.

Baseline systolic blood pressure was higher in the higher weight gain categories, namely

Groups B and C, although no significant difference was observed in baseline heart rate. We observed an increased incidence of hypotension among parturients with overall weight gain of 8–10 kg compared with those who gained >13 kg. The requirement for mephentermine to treat hypotension was also greater in the lower weight gain group. Nevertheless, weight gain during individual trimesters was not significantly associated with the incidence of hypotension or other haemodynamic changes. These findings indicate that overall maternal weight gain during pregnancy may have a greater relationship with the haemodynamic response to subarachnoid blockade than the distribution of weight gain across individual trimesters.

An additional important finding of our study was the significant difference in birth weight among the newborns in the three groups. Inadequate maternal weight gain was associated with lower birth weight compared with the birth weight of newborns delivered to mothers with higher pregnancy weight gain. This observation is consistent with the findings of Siega-Riz et al.^[13] who reported that inadequate maternal weight gain was associated with lower birth weight.

The findings of the present study suggest that inadequate overall maternal weight gain during pregnancy is associated with a greater incidence of hypotension following subarachnoid blockade for caesarean section and an increased requirement for mephentermine. However, weight gain during individual trimesters did not demonstrate a significant association with post-spinal hypotension, heart rate changes, or other haemodynamic alterations. The findings also demonstrate an association between inadequate maternal weight gain and lower neonatal birth weight. These observations highlight the potential importance of overall maternal weight gain in relation to both maternal haemodynamic response to spinal anaesthesia and neonatal birth weight.

CONCLUSION

Based on the findings of our study, inadequate maternal weight gain of less than 11 kg during pregnancy was associated with a lower baseline systolic blood pressure and an increased incidence of hypotension following subarachnoid block during elective caesarean section. Inadequate maternal weight gain was also associated with lower birth weight of the newborn. Therefore, maintaining adequate

weight gain during pregnancy is advisable to promote maternal haemodynamic stability during spinal anaesthesia and to reduce the risk of adverse maternal and fetal outcomes

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