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# Influence of symphysiofundal height, abdominal girth and body mass index on hypotension and vasopressor requirement in cesarean section under spinal anesthesia: a prospective clinical study

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## Abstract

**Background and Aims -** Variability in lumbosacral CSF volume is most contributing factor in cephalad local anesthetic spread in subarachnoid space in pregnancy due to its compressive effects, exaggerated with increased body mass index (BMI). We assessed correlation of symphysiofundal height (SFH), abdominal girth (AG) and BMI with incidence of hypotension, and highest level of sensory blockade. Additionally, requirement of vasopressor, and incidence of nausea, vomiting was also assessed.

**Materials and Methods-** It is a prospective observational study conducted in tertiary care institute. Two hundred American society of Anesthesiologists I and II parturients (age: 20-35 years, weight: 45-80 kg, height: 145-170 cm, BMI: 18-25 cm) undergoing cesarean section under spinal anesthesia were included. SFH, AG and BMI were measured by single obstetrician prior to induction of spinal anesthesia. Hyperbaric bupivacaine 0.5%(H) 10.4 mg (2.2cc) was administered for subarachnoid block. Incidence of hypotension, highest level of sensory blockage, vasopressor requirement and incidence of nausea, vomiting were assessed. All observations were analyzed using Correlation analysis (Spearman's rank test) and $P < 0.05$ was considered to be statistically significant.

**Results:** Incidence of hypotension was statistically significant, with increasing SFH (12.9%- SFH <35 cm, 41.4%- SFH >35; correlation coefficient $\rho = 0.013$), and AG (13% - AG <94 cm, 37.9%- AG >99 cm; correlation coefficient $\rho = 0.05$). Maximum sensory level achieved was significantly higher with increasing SFH and AG. Incidence of hypotension and vasopressor requirement was also greater for higher BMI (BMI>25kg/m$^2$).

**Conclusion:** Study suggests positive correlation between SFH, AG and BMI with incidence of hypotension, maximum level of sensory blockade, increased vasopressor requirement and nausea, vomiting incidence.

**Keywords-** Symphysiofundal height, Abdominal girth, Body mass index, Cesarean section, Spinal anesthesia, Sensory block level.

## Introduction

Spinal anesthesia is the most preferred technique for Cesarean section providing quicker and denser block with failure rate < 1%. [1] However, hypotension is its most common complication and can vary between 55% to 90%, compromising maternal and fetal outcomes. [2]Lumbosacral cerebrospinal fluid (CSF) volume is most contributing factor for cephalad local anesthetic spread in subarachnoid space and higher sensory block level (SBL) especially in pregnant women, due to compressive effects of gravid uterus on inferior vena cava and development of plexus venosus collateral circulation in epidural space. [3] Morbid obesity is further shown to enhance intrathecal cranial spread of local anesthetic due to increase in intra-abdominal pressure leading to increase in pressure in inferior vena cava, and subsequently reduction in epidural space and reduced CSF volume. The severity of hypotension is directly influenced with the level of autonomic block. [4]SFH and AG have classically been used to measure size of gravid uterus and to assess fetal growth during pregnancy and can give an indirect measure of extent of IVC compression, which may influence lumbosacral CSF volume. [5]Hence, we conducted a clinical study with a primary aim to evaluate the influence of SFH, AG and BMI on the spread of local anesthetic (highest sensory block level achieved) and incidence of hypotension and secondary aim of vasopressor requirement and incidence of nausea and vomiting.

## Materials and Methods

This prospective observational study was conducted in a tertiary care institute from October 2019 to January 2020, in accordance with Helsinki Declaration of 1975, as revised in 2000. Institutional ethics committee approval was obtained. Written informed consent was obtained and patient related confidentiality was maintained. Two hundred healthy full-term singleton parturient belonging to ASA 1 and 2, aged between 20 to 35 years, weight between 45 to 80 kg, height between 145 to 170 cm, and BMI between 18 to 25, posted for cesarean section were included. The following parturient were excluded from the study: parturient who refused to give valid informed consent, with placenta previa, pregnancy-induced hypertension, twin pregnancies, significant medical or obstetric morbidity, any absolute contraindication to spinal anesthesia and also those cases which were converted to general anesthesia due to insufficient spinal anesthesia. In this study, we hypothesized about a positive correlation between SFH and AG with the incidence of hypotension. Based upon the study by Prabha Parthasarathy et al, the increase in incidence of hypotension was 78.4% with SFH of 36-40 cm as compared to 16.9% at SFH of 30-35 cm. [3] Sample size was estimated to be 188 with the alpha error of 0.10 and power of 80%. We, however, included 200 parturients in our study to compensate for dropouts and better validation of results. Written informed consent was obtained and a thorough Pre anesthetic Checkup (PAC) was done. BMI was noted, NBM (nil by mouth) status was confirmed and anti-aspiration prophylaxis was taken. SFH was measured from superior margin of the pubic symphysis to the upper margin of uterine fundus in supine position and AG was measured with a tape at lower border of the umbilicus on a horizontal table, in the preoperative preparation room, by the same obstetrician for all the cases which was not revealed to the anesthesiologist. A total of three readings were taken, and the maximum of three values was considered. In the operation theatre, initially 4-6 liters of supplementary oxygen was started. Standard monitors including pulse oximeter, ECG and a noninvasive blood pressure (NIBP) were applied. The baseline values of hemodynamic parameters- heart rate (HR), systolic, diastolic and mean arterial BPs were recorded.

Intravenous line with 18G IV cannula in a large peripheral vein was established and 15 ml/kg of Ringer lactate was infused 15 min before administration of subarachnoid block (SAB). After finishing infusion, the parturient women were converted to the left lateral recumbent position. Spinal block was performed with a 25 Gauge Quincke spinal needle, using midline approach at L3-L4 intervertebral space. After checking the cerebrospinal fluid outflow, 2.2 ml (10.4 mg) of hyperbaric 0.5% bupivacaine, was injected at the rate of 0.2 ml/sec without changing the direction of the bevel. Immediately after injecting the drug, the patient was put in supine position and uterus was transposed to the left by at least 15º by placing a wedge under right buttock, in order to prevent supine hypotensive syndrome. The level of sensory block was considered appropriate at T5-6 and assessed by response to cold sensation by alcohol swab. The maternal hemodynamic parameters: Heart Rate (HR), NIBP and peripheral blood saturation (SpO2) every 2 minutes up to 10 minutes and then every 10 minutes until the end of operation. Intravenous fluids were administered at a rate of 100 ml in 10 minutes. Hypotension was defined as a drop in mean arterial BP by more than 20% of the resting blood pressure or when the systolic blood pressure dropped below 90 mmHg and was treated with injection ephedrine (6 mg). Injection ephedrine (6 mg) was repeated if the blood pressure drop continued after the blood pressure measurement in 2-minute intervals or when the parturient women complained of nausea and vomiting. Bradycardia was defined as HR <60 beats/min and was treated with injection atropine 0.6 mg IV. Intravenous injection of fentanyl (80 μg) was carried out when the patients complained of visceral pain during the operation or the spinal anesthesia was converted to general anesthesia when the injection was considered inappropriate. The weight of the newborn baby was recorded after the delivery. The side effects such as hypotension, nausea and vomiting, respiratory depression or pruritus were observed and recorded. Parturients in whom the level of the sensory block did not reach T6 level, those requiring additional oxytocics, and those with excessive intraoperative bleed were excluded from the study. The influence of SFH, AG and BMI on incidence of hypotension and the maximum level of sensory block were the primary outcome measures. The degree of hypotension as measured by vasopressor (ephedrine) usage and the incidence of nausea and vomiting were secondary measures. We also observed the relationship between BMI and the use of vasopressor.

**Statistical Analysis**

Correlation analysis (Spearman's rank test) was performed to find the correlations of the SFH and AG with the incidence of hypotension and level of maximum sensory blockade. For analytical purposes, SFH and AG were presented as ordinal data with defined class intervals. The incidence of hypotension, level of sensory block, and vasopressor use were categorized accordingly. Chi-square test was applied for categorical data, and one-way ANOVA test was applied for discrete data. $P < 0.05$ was considered statistically significant for all the tests. The data were analyzed using SPSS 22 version software (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.).

**Results**

All the enrolled parturients completed the study, and none of them were excluded. The mean age, weight, height & BMI of parturients enrolled for the study were 24.4 ± 1.66 years, 63.07 ± 1.53 kg, 153.21 ± 1.13 cm & 18.31±5.94 respectively. Mean onset of sensory block was 2.41 ±0.49 whereas mean onset of motor block was 4.27 ±0.72 minutes. Maximum sensory block was achieved at T4 level in 83.5% patients. (Table 1)The incidence of hypotension in the cesarean section under spinal anesthesia using bupivacaine 0.5% (H) was 71.5% (143 out of 200 parturients) (Figure 1). The mean SFH was higher in parturients with hypotension (38.88 ± 5.39 cm) compared to those without hypotension (34.98 ± 6.11 cm). The mean AG was higher in parturients with hypotension (101.9 ± 8.82 cm) compared to those without hypotension (98.02 ± 9.57 cm). The incidence of hypotension was higher with increasing SFH (12.9% with SFH <35 cm, 41.4% with SFH >35; correlation coefficient ρ = 0.013). Similarly, incidence of hypotension was higher with increasing AG (13% with AG between <94 cm, 25% with AG 95–99 cm, 37.9% with AG >99 cm; correlation coefficient ρ =0.05) and both were statistically significant (P < 0.05). Similarly, rescue dose of ephedrine was higher with SFH >35cm and AG >95 (Table 2).Maximum sensory level achieved was observed to be increasing with increasing SFH and AG, the association was statistically significant (p<0.05). (Table 3) (Figure 2).Spearman rho correlation coefficient observed a highly statistical correlation of SFH and AG with hypotension (p<0.01) and maximum sensory level achieved (p<0.01). (Table 4)Incidence of hypotension was greater in parturients with BMI >25kg/m2 (91.17%) as compared to parturients with BMI ≤25 Kg/m2 (1.51%) (Figure 3), similarly requirement of vasopressor was greater in the parturients with BMI >25kg/m2 (86.76%) as compared to parturients with BMI ≤25 Kg/m2 (3.03%) (p<0.05). (Table 5) (Figure 4)Incidence of nausea &vomiting was greater in the parturients with SFH >35cm (79.47%) as compared to parturients with SFH ≤35 cm (8.16%). Similarly, incidence of nausea & vomiting was also greater in parturients with AG>95cm (81.88%) as compared to parturients with AG ≤95 cm (16.43%) (p<0.05). (Table 6) (Figure 5).

**Discussion**

In our study, we found a positive correlation of SFH, AG and BMI with the incidence of hypotension, and the maximum level of sensory blockade, measured as the primary outcome. And increased use of vasopressor, and a greater incidence of nausea, vomiting which were measured as the secondary outcome. Spinal anesthesia is the most preferred anesthesia for cesarean section. However, hypotension is its most widespread complication, with the level of autonomic block bearing direct influence on severity of hypotension. [6] Initially, Holmes et al and Lees et al indicated that the compression of the vena cava by gravid uterus decreased the venous return and reduced cardiac output leading to hypotension. However, contrary to the traditional belief, the change in venous capacitance due to sympathetic blockade rather than a decrease in cardiac output have been postulated as a major cause for hypotension in these patients. [7,8] Many factors are likely to affect the spread of sensory block level (SBL), but variability in lumbosacral CSF volume is the most contributing factor. [9,10] In case of parturient women, pressure on the IVC by the gravid uterus causes expansion of the lumbar vein and vertebral artery around the spinal cavity and shrinkage of the subarachnoid space with the reduction of CSF volume that may augment the diffusion of local anesthetic in cephalad direction. [11] Onuki et al showed that the CSF volume ranged from approximately 25 to 45 ml in 18 pregnant women. Therefore, the range of sensory block level after injection of local anesthetics into CSF is unpredictable. [12] In the present study, we hypothesized that the SBL ascencion rate may serve as an indicator of the trend of SBL spread after spinal anesthesia. Morbid obesity (BMI ≥40 Kg/m2) is an independent factor for higher intrathecal local anesthetic spread and spinal hypotension and approximately 40-60% of patients still need to use vasopressor agents such as ephedrine or phenylephrine, despite applying different treatment methods such as crystalloid and colloid and the avoidance of aortocaval compression. Hence, many studies have rec¬ommended a reduced spinal dose in morbidly obese women, presumably due to lower cerebrospinal fluid volume. [13,14,15] Rodrigues FR and Brandao MJN found a positive relationship between increased BMI and the incidence of hypotension in a study in obese women undergoing caesarean section under neuraxial anesthesia. [16]The size of the enlarged uterus may influence the local anesthetic spread by affecting the pressure in the subarachnoid space, thereby influencing sympathetic blockade. SFH and AG measurements are generally used in obstetric practice to clinically assess the intrauterine growth of the fetus and can be used as an indirect measure of the extent of IVC compression, and in turn the lumbosacral CSF volume. [5]Parthasarathy et al found a statistically significant positive correlation between SFH and abdominal girth with the incidence of hypotension in parturients undergoing cesarean section under spinal anesthesia using bupivacaine with fentanyl as adjuvant. [3]Vasopressors are routinely being used to counteract hypotension after neuraxial anesthesia in cesarean section. Chung et al found a statistically significant correlation between the SFH and ephedrine dose required in a study conducted to determine the relationship between SFH and the dose of IV ephedrine administered for hypotension in spinal anesthesia for cesarean sections, which is in agreement with the observations of our study. [17]In our study, we found that SFH, AG, and BMI were strongly correlated with the amount of administered ephedrine. This may be because with increased SFH, AG and BMI the inferior vena cava was more strongly pressed and hence more chances of hypotension.Maternal hypotension is shown to jeopardize placental perfusion, compromising fetal outcome, and can cause symptoms such as nausea, vomiting, and dizziness. The causes of nausea and vomiting include cerebral ischemia by blood pressure drop, hyperfunction of the vagus nerve, intraoperative intestine traction, and preanesthetic administration. [18] The incidence and severity of spinal hypotension may be reduced by administration of a crystalloid preload and the use of left lateral tilt or placing a small wedge under the right hip. [19] Whilst these measures should be considered mandatory, they do not prevent completely the occurrence of hypotension, and administration of a vasopressor is often required. [20] When hypotension, nausea, and vomiting occurred after spinal anesthesia in this study, ephedrine was administrated to treat the nausea and vomiting accompanying hypotension. In the study of Kol et al, it was reported that the incidence of hypotension, as well as the incidence of nausea and vomiting, was effectively reduced in the group of parturient women to whom ephedrine was administrated during the spinal anesthesia for Cesarean section. [21]Though lumbosacral CSF volume is the most important factor contributing to the variability in the ascend of spinal sensory anesthesia, there are other factors that significantly affect are: the physical characteristics of CSF and the solution injected (hyperbaric, isobaric or hypobaric), baricity of the solution, the clinical technique used and the patient's general features such as height, weight, body mass index of the patient can significantly influence the occurrence of hypotension in the parturient. [22,23,24] Contrary to the popular belief, rapid intrathecal injection of hyperbaric bupivacaine does not affect level of spinal anesthesia or the incidence of hypotension and nausea in parturients. [25]Our study has several strengths: In our present study, an attempt was made to avoid most of the confounding variables by patient selection within a narrow range of height and weight and by adopting uniform measures like single use of hyperbaric bupivacaine, 15-degree left lateral uterine displacement by placing wedge under right hip and less use of ephedrine. To exclude the variations resulting from measurements by different individuals, SFH and AG were measured by same obstetrician, and the data was not provided to the anesthetist. In contrast to the observations of earlier studies, there was a significant positive correlation of the SFH and AG with the maximum level of sensory block achieved and the incidence of hypotension in our study. [26,27] We also found a positive correlation between increased use of vasopressor and increased chances of nausea, vomiting with increased SFH and AG. The hypotension and the requirement of vasopressor was also found to be more severe in obese parturients (BMI>25kg/m2).However, this study was subject to following limitations. First, we used fixed dose of hyperbaric bupivacaine in place of patient's height and weight adjusted dose. However, recent studies have highlighted the benefits of height and weight adjusted spinal dose regimen for cesarean section. [18] Secondly, this study was performed using non-invasive arterial BP monitoring. Considering the marked changes in hemodynamics that occur after spinal anesthesia, a timely and accurate outcome can be acquired by invasive arterial BP monitoring. However, we believe that the results of our study also provide clinical guidance because non-invasive arterial BP monitoring is a routine monitoring technique. Thirdly, the CSF volume was not measured with magnetic resonance imaging in the current study, which may provide objective evidence of influence of uterine size on the extent of IVC compression and in turn the lumbosacral subarachnoid space volume. Therefore, whether the unpredictable sensory block level ascension range was influenced by the variability in the CSF volume remains unclear. Future studies using ultrasound and other imaging modalities can be considered to establish a correlation between SFH and AG and pressure changes in IVC and subarachnoid space and also to measure the incidence and severity of hypotension.

Table 1: Demographic variables of patients & Characteristics of spinal anesthesia

| Patients characteristics | Mean | Standard deviation (SD) |
|---|---|---|
| Age(years) | 24.4 | 1.66 |
| Weight(kg) | 63.07 | 1.53 |
| Height(cm) | 153.21 | 1.13 |
| BMI | 18.31 | 5.94 |
| Symphysial Height(cm) | 36.38 | 2.55 |
| Abdominal girth(cm) | 99.57 | 4.57 |
| **Spinal Anesthesia** | **Mean** | **Standard deviation (SD)** |
| Onset of sensory block(min.) | 2.41 | 0.49 |
| Onset of motor bock(min.) | 4.27 | 0.72 |
| **Maximum sensory block** | **Frequency** | **Percentage** |
| T4 | 167 | 83.5 |
| T6 | 33 | 16.5 |

Table 2: Association of Hypotension and rescue dose of Ephedrine with SFH and abdominal girth.

| Parameters | | Total number of parturients | Hypotension | | p-value | Rescue ephedrine dose in mg(mean±SD) |
|---|---|---|---|---|---|---|
| Symphysiofundal height | | | Yes (%) | No (%) | | |
| | ≤35cm | 49 | 14 (28.5) | 35 (71.5) | 0.01 3 | 5.08±0.63 |
| | >35cm | 151 | 143 94.7) | 08(5.30) | | 8.94±0.05 |
| Abdominal girth | ≤95cm | 73 | 3 (4.11) | 70(95.8) | 0.05 | 6.16±3.1 |
| | >95cm | 127 | 123 96.8) | 4(3.2) | | 10.62±1.6 |

Table 3: Association of maximum sensory level with SFH and abdominal girth.

| | | | Maximum Sensory Level | | p-value |
|---|---|---|---|---|---|
| | | Total | T4(%) | T6(%) | |
| Symphysiofundal Height | ≤35 cm | 49 | 02(4.08) | 47(95.91) | 0.002 |
| | >35cm | 151 | 115(76.15) | 36(23.8) | <0.0001 |
| Abdominal Girth | <95cm | 73 | 01(1.32) | 72(98.63) | <0.0001 |
| | >95cm | 127 | 117(92.1) | 10(7.87) | <0.0001 |

Table 4: Correlation of hypotension and maximum sensory level with SFH and abdominal girth

| | Spearman rho coefficient | Hypotension | Maximum Sensory Level |
|---|---|---|---|
| Symphysiofundal height | Coefficient | 0.33 | 0.35 |
| | P value | 0.01 | 0.006 |
| Abdominal girth | Coefficient | 0.92 | 0.32 |
| | P value | 0.001 | 0.01 |

Table 5: Comparison of Body mass index (BMI) with the incidence of hypotension and requirement of vasopressor.

| Variable | Total number of parturients | Incidence of hypotension in parturients | Percentage (%) | p-value |
|---|---|---|---|---|
| BMI >25 Kg/m$^2$ n=68 | 68 | 62 | 91.17 | 0.014 |
| BMI ≤25 Kg/m$^2$ n=132 | 132 | 2 | 1.51 | 0.24 |
| Variable | Total number of parturients | Requirement of vasopressor in parturients | Percentage (%) | p-value |
| BMI >25 Kg/m$^2$ n=68 | 68 | 59 | 86.76 | 0.022 |
| BMI ≤25 Kg/m$^2$ n=132 | 132 | 4 | 3.03 | 0.48 |

Table 6: Comparison of Symphysiofundal Height and Abdominal Girth with the incidence of Nausea &Vomiting.

| | | Total number of parturients | Incidence of nausea & vomiting in parturients | Percentage (%) | p-value |
|---|---|---|---|---|---|
| Symphysiofundal Height(cm) | ≤35 cm | 49 | 04 | 8.16% | 0.22 |
| | >35cm | 151 | 120 | 79.47% | 0.03 |
| Abdominal Girth(cm) | <95cm | 73 | 12 | 16.43% | 0.39 |
| | >95cm | 127 | 104 | 81.88% | 0.031 |

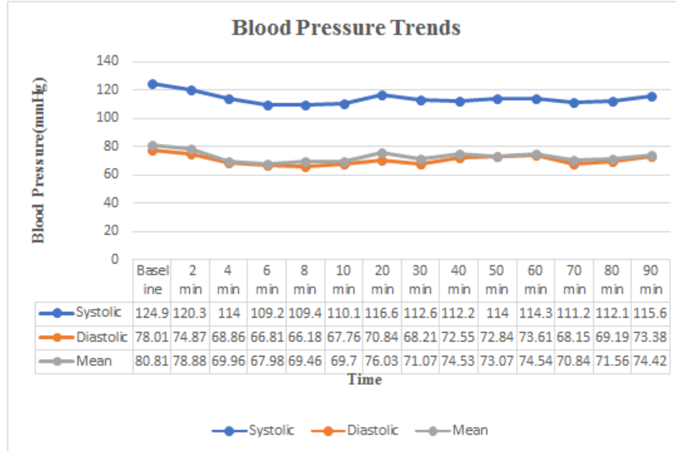


Figure 1: Blood pressure trends among the parturients

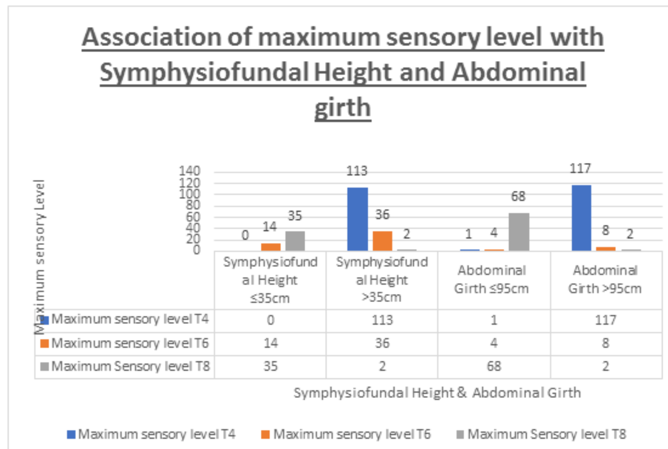


Figure 2: Association of maximum sensory level with SFH and abdominal girth

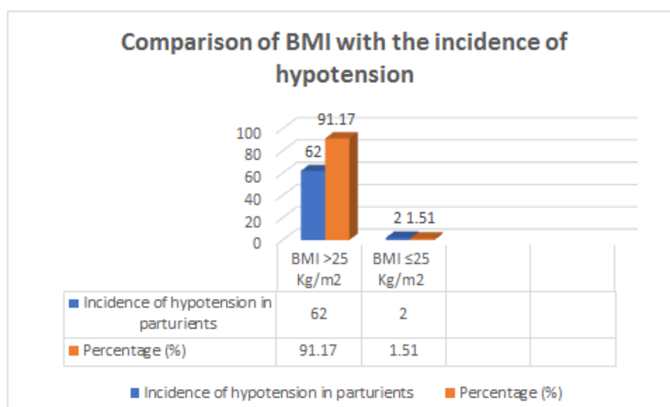


Figure 3: Comparison of BMI with the incidence of hypotension

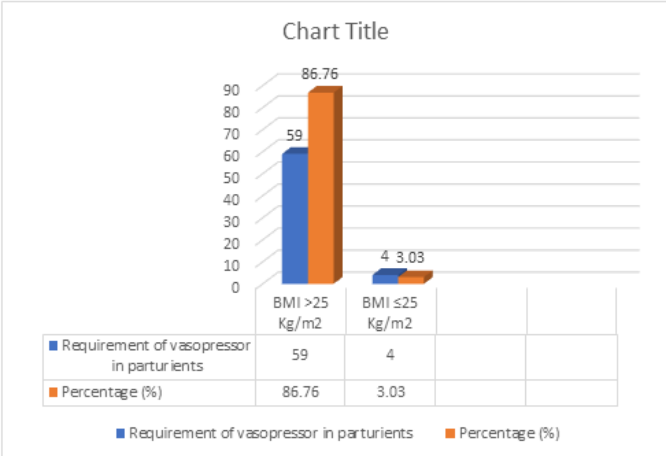


Figure 4: Comparison of BMI with the requirement of vasopressor.

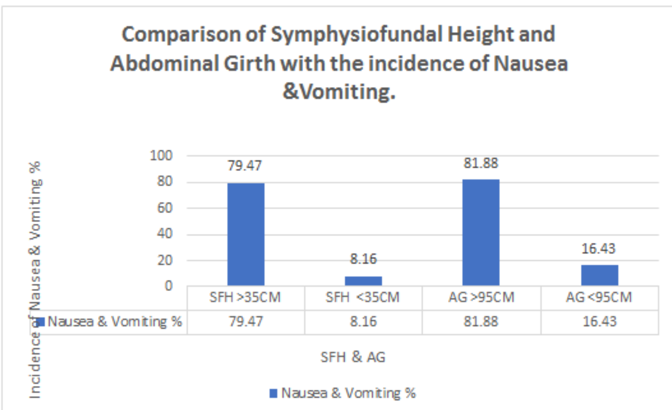


Figure 5: Comparison of Symphysiofundal Height and Abdominal Girth with the incidence of Nausea &Vomiting.

**Conclusion**

The results of our study suggest positive correlation between SFH, AG and BMI with the incidence of hypotension and the maximum level of spinal blockade. There was also increased use of vasopressor and greater incidence of nausea, vomiting with increased SFH, AG and BMI.

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