

Effect of Symphysiofundal Height and Abdominal Girth on Occurrence of Hypotension in Caesarian Section Patient's under Spinal Anesthesia using Bupivacaine and Fentanyl as an Adjuvant – At A Tertiary Care Center

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Abstract:

Introduction: Post-spinal hypotension remains one of the most common and clinically significant complications of spinal anaesthesia for caesarean section. Although several maternal and obstetric factors influence the extent of hypotension and sensory block spread, prediction remains difficult. Symphysiofundal height (SFH) and abdominal girth (AG) are simple, non-invasive bedside measurements that may reflect uterine size and intra-abdominal pressure and potentially influence the spread of intrathecal anaesthesia and haemodynamic response. The present study evaluated the relationship of SFH and AG with post-spinal hypotension and other anaesthetic outcomes in parturients undergoing caesarean section under spinal anaesthesia using bupivacaine with fentanyl as an adjuvant.

Aim: To study the effect of symphysiofundal height (SFH) and abdominal girth (AG) on the occurrence of hypotension in patients undergoing caesarean section under spinal anaesthesia using bupivacaine with fentanyl as an adjuvant, and to assess their association with sensory block level, haemodynamic changes, vasopressor requirement, recovery characteristics, and anaesthesia-related side effects.

Result: This quasi-experimental observational study was conducted over 18 months among 146 pregnant women undergoing elective caesarean section under spinal anaesthesia. The mean height was 154.8 ± 5.3 cm, mean weight 68.4 ± 8.7 kg, mean BMI 28.5 ± 3.6 kg/m², mean gestational age 38.6 ± 0.9 weeks, and mean estimated fetal weight 3.01 ± 0.38 kg. Overall, post-spinal hypotension occurred in 80/146 (54.8%) participants. Hypotension increased progressively with SFH, from 4 (18.2%) in the 30–32 cm group to 14 (29.2%), 40 (78.4%), and 22 (88.0%) in the 33–35, 36–38, and 39–40 cm groups, respectively ($p < 0.001$). Similarly, hypotension increased with AG from 1 (5.3%) in the 85–89 cm group to 31.8%, 75.0%, and 85.2% in the 90–94, 95–99, and 100–104 cm groups, respectively ($p < 0.001$). SFH and AG demonstrated positive correlations with hypotension incidence ($r_s = +0.612$ and $+0.648$, respectively; $p < 0.001$), sensory block level ($r_s = +0.578$ and $+0.603$, respectively; $p < 0.001$), and ephedrine requirement ($r = +0.534$ and $+0.572$, respectively; $p < 0.001$). Higher SFH and AG were also associated with greater cephalad sensory block spread and increased anaesthesia-related side effects.

Conclusion: Higher symphysiofundal height and abdominal girth are significantly associated with increased incidence and severity of post-spinal hypotension, higher sensory block levels, and greater vasopressor requirement during caesarean section. SFH and AG are simple, non-invasive, and readily available bedside measurements that may be useful for preoperative risk stratification and anticipation of haemodynamic instability. Incorporating these measurements into routine obstetric anaesthetic assessment may facilitate closer monitoring, early vasopressor preparedness, and more individualized haemodynamic management.

Keywords: Symphysiofundal Height; Abdominal Girth; Spinal Anaesthesia; Caesarean Section; Post-Spinal Hypotension; Sensory Block; Vasopressor; Bupivacaine; Fentanyl; Obstetric Anaesthesia.

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Introduction

Caesarean section is one of the most frequently performed surgical procedures worldwide, and its

use continues to rise across both high-income and low- and middle-income countries. Recent global

estimates suggest that about one in five births now occurs by caesarean delivery, and the worldwide rate is projected to increase further over this decade. As caesarean delivery becomes more common, optimization of perioperative maternal and fetal safety becomes increasingly important, especially in institutions managing large volumes of obstetric patients. [1]

For most elective and many urgent caesarean deliveries, neuraxial anesthesia is preferred over general anesthesia because it avoids airway manipulation, limits fetal exposure to anesthetic drugs, provides dense surgical anesthesia, and is associated with better postoperative analgesia and less blood loss. Among neuraxial techniques, spinal anesthesia remains especially popular because it is rapid, reliable, technically straightforward, and well suited to caesarean delivery. However, its major drawback is maternal hypotension, a complication that remains common despite modern preventive strategies. [2]

Spinal-anesthesia-induced hypotension during caesarean section is clinically important because it is associated with maternal symptoms such as nausea, vomiting, dizziness, and occasionally reduced consciousness, and it can also impair uteroplacental perfusion, with potential consequences for fetal oxygenation and acid-base status. A recent systematic review of prospective observational studies found that the reported rate of hypotension varied widely, from 29% to 80%, depending on definitions and perioperative management protocols, underscoring both the frequency of the problem and the lack of uniformity in its assessment. [3]

The physiological basis of hypotension after spinal anesthesia in parturients is multifactorial. Sympathetic blockade causes arterial and venous vasodilation, decreases venous return, and reduces cardiac output. In pregnancy, these effects are compounded by aortocaval compression from the gravid uterus and by pregnancy-related changes in venous capacitance and sensitivity to local anesthetics. Consequently, caesarean patients represent a uniquely vulnerable population in whom even standard spinal doses can produce clinically significant hemodynamic instability. [2]

Because of this risk, substantial work has been done on prevention and treatment, particularly with fluid strategies and vasopressors. Contemporary evidence supports vasopressor-based prophylaxis and treatment, with phenylephrine remaining the most established first-line agent and norepinephrine increasingly discussed as a promising alternative because of its more favorable cardiac profile. Yet even with improved management, hypotension still occurs frequently, which means that treatment alone

is not enough; better preoperative prediction is also needed. [4,5]

This need for prediction has driven growing interest in maternal anthropometric and physiologic markers. Larger uterine size and greater abdominal dimensions may reflect greater intra-abdominal pressure, more marked aortocaval compression, and altered cerebrospinal fluid dynamics, all of which can influence cephalad spread of intrathecal local anesthetic and thereby increase sympathetic block height and the risk of hypotension. In practice, clinicians need simple bedside predictors that are inexpensive, reproducible, and usable before spinal injection. [2,3]

Over the last few years, several studies have examined anthropometric predictors of spinal block height and hemodynamic changes. Kim et al. found that body mass index and abdominal circumference-to-height ratio correlated with maximal sensory block level, and that BMI, body weight, and supine abdominal circumference-to-height ratio were higher in women who developed hypotension. These findings support the view that body habitus and abdominal dimensions are clinically relevant in obstetric spinal anesthesia. [6]

However, the literature is not fully consistent. Thomard et al. reported that women with larger abdominal circumference had greater falls in mean arterial pressure from baseline, but the incidence of hypotension defined by standard criteria did not differ significantly between groups. In contrast, Suryawanshi and Roshni reported that larger abdominal circumference was associated with a significantly higher rate of hypotension, more pronounced hemodynamic changes, higher spinal levels, and greater ephedrine requirement. Taken together, these studies suggest that abdominal dimension probably matters, but the magnitude and clinical expression of its effect remain uncertain. [7,8]

Broader risk-factor studies reinforce this uncertainty. Li et al. identified maternal BMI, baseline systolic blood pressure, baseline heart rate, multiparity, and larger fetal weight as significant contributors to more severe post-spinal hypotension, even when vasopressors were used. Similarly, the systematic review by Yu et al. concluded that no single predictor had sufficiently robust and consistent performance for routine universal use and highlighted the substantial variability introduced by differing definitions of hypotension, fluid loading regimens, and vasopressor protocols. [3,9]

A critical appraisal of previous research shows several important limitations. Most studies have been single-center observational studies, limiting generalizability across populations and practice settings. Anthropometric variables studied have also

been heterogeneous, including abdominal circumference, BMI, waist-to-hip ratio, abdominal circumference-to-height ratio, vertebral column length, fetal weight, and composite indices. Furthermore, studies have often prioritized surrogate endpoints such as sensory block height or vasopressor dose rather than a clinically integrated assessment of hypotension risk. Substantial methodological heterogeneity also exists in definitions of hypotension, timing of measurement, local anesthetic dose, intrathecal adjuvants, fluid loading, positioning, and vasopressor use. These limitations make direct comparison difficult and reduce the certainty with which existing results can be translated into routine practice. [3,6-9]

Within this context, the present study addresses a clinically relevant and comparatively underexplored question: whether symphysiofundal height and abdominal girth—two simple, inexpensive, bedside obstetric measurements—are associated with hypotension during caesarean section under spinal anesthesia with bupivacaine and fentanyl. Both measurements are easy to obtain preoperatively, require no special equipment, and may better reflect uterine size and abdominal distension than generalized obesity markers alone. If shown to correlate with hypotension risk, they may help anesthesiologists identify high-risk patients before spinal anesthesia and adjust monitoring, positioning, fluid management, and vasopressor readiness more proactively.

The rationale for this study is therefore strong. Post-spinal hypotension during caesarean section remains common, clinically relevant, and incompletely predictable despite advances in obstetric anesthesia. Existing evidence suggests that maternal body habitus and abdominal dimensions may influence spinal block characteristics and hemodynamic response, but prior findings are inconsistent and methodologically heterogeneous. There remains a specific gap regarding the combined assessment of symphysiofundal height and abdominal girth in women receiving a standardized spinal anesthetic with bupivacaine and fentanyl. Filling this gap may help refine preoperative risk assessment and support more individualized obstetric anesthetic care. [2,3,5,6]

In summary, caesarean delivery is increasingly common, spinal anesthesia remains the preferred technique for many parturients, and post-spinal hypotension continues to be one of its most frequent and clinically consequential complications. Current research supports the importance of maternal anthropometry but does not yet provide a definitive, simple bedside predictor. Against this background, studying the relationship of symphysiofundal height and abdominal girth with hypotension in caesarean section under spinal anesthesia is justified, timely, and likely to have practical value for perioperative

obstetric care. [1-3,5,6] Hence, the present study was conducted to study the effect of symphysiofundal height (SFH) and abdominal girth (AG) on the occurrence of hypotension in patients undergoing caesarean section under spinal anesthesia using bupivacaine with fentanyl as an adjuvant.

Material and Methods

The present study was conducted as a quasi-experimental observational study at a tertiary care teaching hospital for a period of 18 months after obtaining approval from the Institutional Ethics Committee amongst pregnant women scheduled for elective caesarean section under spinal anesthesia, who fulfilled the inclusion criteria. The sample size was calculated based on a previously reported correlation coefficient of 0.338 between symphysiofundal height (SFH), abdominal girth (AG), and incidence of hypotension. Using Fisher's arctanh transformation with a confidence level of 99% and power of 90%, the required sample size was estimated to be 146 participants.

Inclusion Criteria:

- Pregnant women aged ≥ 18 years
- Patients scheduled for elective caesarean section under spinal anesthesia
- Patients who provided written informed consent

Exclusion Criteria:

- Patients with cardiovascular disorders predisposing to hypotension
- Known allergy to bupivacaine or fentanyl
- History of recent abdominal surgery or caesarean section within 6 months
- Patients with coagulopathy or contraindications to spinal anesthesia
- Patients with pre-eclampsia or hypertensive disorders of pregnancy
- Patients who did not consent to participate

Study Procedure: After obtaining written informed consent, all participants underwent a preoperative anesthetic evaluation including heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure were recorded. Standard monitoring devices such as electrocardiogram (ECG), pulse oximeter (SpO₂), and non-invasive blood pressure (NIBP) were attached.

Symphysio-fundal height (SFH) was measured from the upper margin of the symphysis pubis to the highest point of the uterine fundus in the supine position. Abdominal girth (AG) was measured at the level of the umbilicus using a measuring tape.

Under strict aseptic precautions, spinal anesthesia was administered using a 27-gauge Quincke needle via the midline approach with 0.5% hyperbaric bupivacaine with fentanyl was administered

intrathecally. Immediately after the procedure, patients were placed in the supine position. Hemodynamic parameters including blood pressure, heart rate, respiratory rate, and oxygen saturation were monitored at regular intervals throughout the intraoperative period.

Outcome Measures

Primary Outcome: Incidence of hypotension in relation to SFH and AG.

Secondary Outcomes:

- Correlation of SFH and AG with spread and level of spinal anesthesia
- Hemodynamic changes (blood pressure and heart rate variations)
- Requirement of vasopressors (ephedrine)
- Incidence of adverse effects such as nausea, vomiting, and shivering
- Recovery profile, including sensory and motor block regression

Results:

Table 1: Anthropometric and Obstetric Profile of Study Participants (N = 146)

Parameter	Mean $\pm$ SD	Range
Height (cm)	154.8 $\pm$ 5.3	141–168
Weight (kg)	68.4 $\pm$ 8.7	48–96
BMI (kg/m ²)	28.5 $\pm$ 3.6	20.1–40.2
Gestational age (weeks)	38.6 $\pm$ 0.9	37–41
Gravidity	1.9 $\pm$ 0.8	1–4
Parity	0.8 $\pm$ 0.6	0–3
Fetal weight estimate (kg)	3.01 $\pm$ 0.38	2.1–4.2

Table 1 described the baseline anthropometric and obstetric profile of the study population. The mean height of participants was 154.8 $\pm$ 5.3 cm, with a range of 141–168 cm, while the mean body weight was 68.4 $\pm$ 8.7 kg, ranging from 48 to 96 kg. The mean BMI was 28.5 $\pm$ 3.6 kg/m², indicating that the study population was, on average, in the overweight

category. The mean gestational age was 38.6 $\pm$ 0.9 weeks, ranging from 37 to 41 weeks, suggesting that most participants were term pregnancies. The mean gravidity and parity were 1.9 $\pm$ 0.8 and 0.8 $\pm$ 0.6, respectively. The estimated fetal weight was 3.01 $\pm$ 0.38 kg, with a range of 2.1–4.2 kg.

Table 2: Incidence and Severity of Hypotension by Symphysiofundal Height Category (N = 146)

SFH Category	n	Hypotension n	Hypotension %	No Hypotension n	No Hypotension %	Mean Fall in SBP (mmHg)	p-value
30–32 cm	22	4	18.2	18	81.8	−0.4 $\pm$ 0.6	p < 0.001
33–35 cm	48	14	29.2	34	70.8	−5.2 $\pm$ 3.4	
36–38 cm	51	40	78.4	11	21.6	−16.8 $\pm$ 5.7	
39–40 cm	25	22	88.0	3	12.0	−22.4 $\pm$ 6.3	
Total	146	80	54.8*	66	45.2		

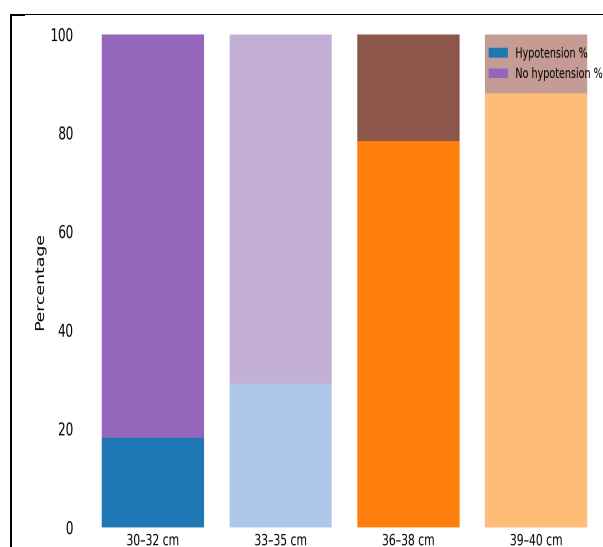


Figure 1: Incidence of hypotension according to symphysiofundal height category.

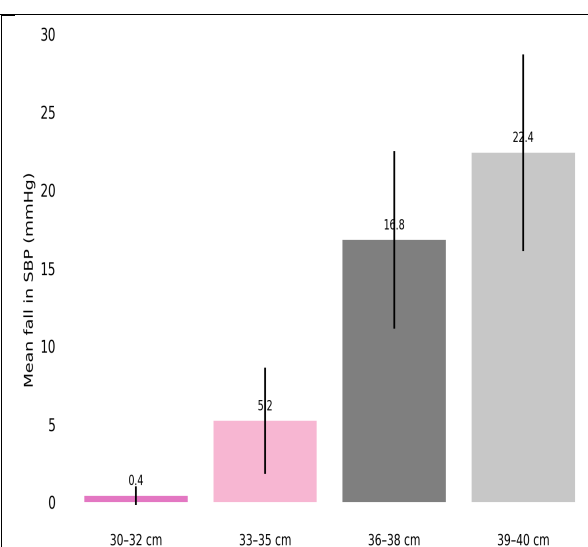


Figure 2: Mean fall in systolic blood pressure according to symphysiofundal height category.

Note: Values expressed as n (%) for categorical and Mean $\pm$ SD for continuous data. $p < 0.001$ for trend across SFH categories (Chi-square test for trend). *Overall incidence 54.8% (80/146). SBP = Systolic Blood Pressure.

Table 2 demonstrated a progressive increase in hypotension with increasing symphysiofundal height. In the 30–32 cm SFH group, hypotension occurred in 4 participants (18.2%), while 18 participants (81.8%) did not develop hypotension. In

the 33–35 cm group, hypotension was observed in 14 participants (29.2%). A marked rise was seen in the 36–38 cm group, where 40 participants (78.4%) developed hypotension. The highest frequency was observed in the 39–40 cm group, with 22 participants (88.0%) developing hypotension. The mean fall in systolic blood pressure also increased across SFH categories, from -0.4 ± 0.6 mmHg in the 30–32 cm group to -22.4 ± 6.3 mmHg in the 39–40 cm group. The association was statistically significant with $p < 0.001$.

Table 3: Incidence of Hypotension by Abdominal Girth Category (N = 146)

AG Category	n	Hypo-tension n	Hypo-tension %	No Hypotension n	No Hypotension %	p-value
85–89 cm	19	1	5.3	18	94.7	–
90–94 cm	44	14	31.8	30	68.2	0.041
95–99 cm	56	42	75.0	14	25.0	< 0.001
100–104 cm	27	23	85.2	4	14.8	< 0.001
Total	146	80	54.8	66	45.2	< 0.001

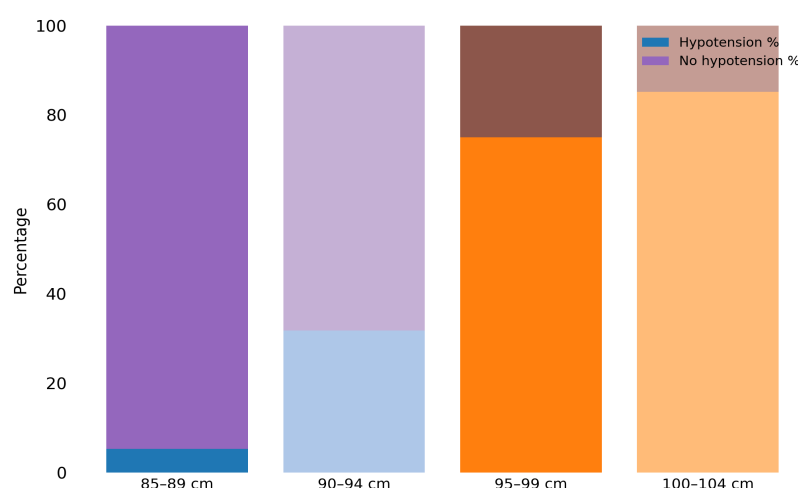


Figure 3: Incidence of hypotension according to abdominal girth category.

Table 3 showed that the incidence of hypotension increased with increasing abdominal girth. Among participants with abdominal girth of 85–89 cm, only 1 participant (5.3%) developed hypotension, while 18 participants (94.7%) did not. In the 90–94 cm group, hypotension was seen in 14 participants

(31.8%). In the 95–99 cm group, 42 participants (75.0%) developed hypotension, and in the 100–104 cm group, hypotension occurred in 23 participants (85.2%). The association between abdominal girth and hypotension was statistically significant, with $p < 0.001$ overall.

Table 4: Correlation Coefficients: SFH and AG with Haemodynamic and Block Outcomes (N = 146)

Variable Pair	Test	r / r _s	95% CI Width	p-value	Strength	Direction
SFH vs. Incidence of hypotension	Spearman (r _s)	+0.612	0.0019	< 0.001	Moderate-Strong	Positive
AG vs. Incidence of hypotension	Spearman (r _s)	+0.648	0.0017	< 0.001	Moderate-Strong	Positive
SFH vs. Highest sensory block level	Spearman (r _s)	+0.578	0.0021	< 0.001	Moderate	Positive
AG vs. Highest sensory block level	Spearman (r _s)	+0.603	0.0020	< 0.001	Moderate	Positive
SFH vs. Ephedrine dose required	Pearson (r)	+0.534	0.0024	< 0.001	Moderate	Positive
AG vs. Ephedrine dose required	Pearson (r)	+0.572	0.0022	< 0.001	Moderate	Positive

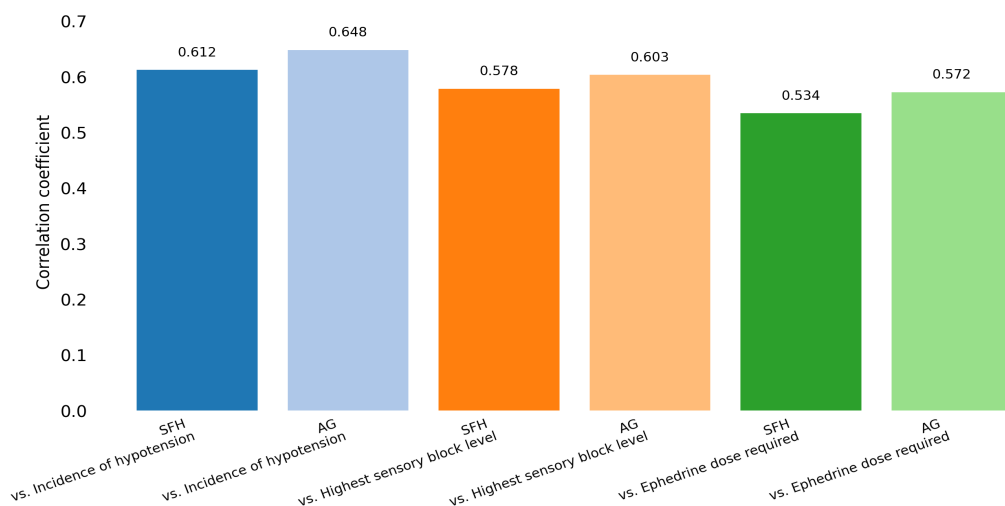


Figure 4: Correlation coefficients of SFH and AG with haemodynamic and block outcomes.

Table 4 presented correlation analyses between anthropometric variables and clinical outcomes. SFH showed a moderate-to-strong positive correlation with incidence of hypotension, with Spearman's $r_s = +0.612$ and $p < 0.001$. Abdominal girth also showed a moderate-to-strong positive correlation with hypotension, with $r_s = +0.648$ and $p < 0.001$. SFH correlated positively with highest sensory block level, with $r_s = +0.578$, while abdominal girth showed a similar positive

correlation with sensory block level, with $r_s = +0.603$; both were statistically significant. Ephedrine dose requirement also increased with SFH and abdominal girth, with Pearson's $r = +0.534$ and $+0.572$, respectively, both with $p < 0.001$. These findings suggested that higher SFH and abdominal girth were associated with greater hypotension risk, higher sensory block level, and increased vasopressor requirement.

Table 5: Distribution of Highest Sensory Block Level by Abdominal Girth Category (N = 146)

AG Category	n	Below T8 (n, %)	T8 to T7 (n, %)	T6 to T5 (n, %)	T4 or above (n, %)	Mean Block Level	p-value
85–89 cm	19	0 (0.0%)	14 (73.7%)	5 (26.3%)	0 (0.0%)	$T7.4 \pm 0.5$	p < 0.001
90–94 cm	44	0 (0.0%)	10 (22.7%)	28 (63.6%)	6 (13.6%)	$T5.9 \pm 0.7$	
95–99 cm	56	3 (5.4%)	6 (10.7%)	20 (35.7%)	27 (48.2%)	$T4.5 \pm 0.9$	
100–104 cm	27	5 (18.5%)	2 (7.4%)	11 (40.7%)	9 (33.3%)	$T4.0 \pm 1.0$	
Total	146	8 (5.5%)	32 (21.9%)	64 (43.8%)	42 (28.8%)	$T5.2 \pm 1.1$	

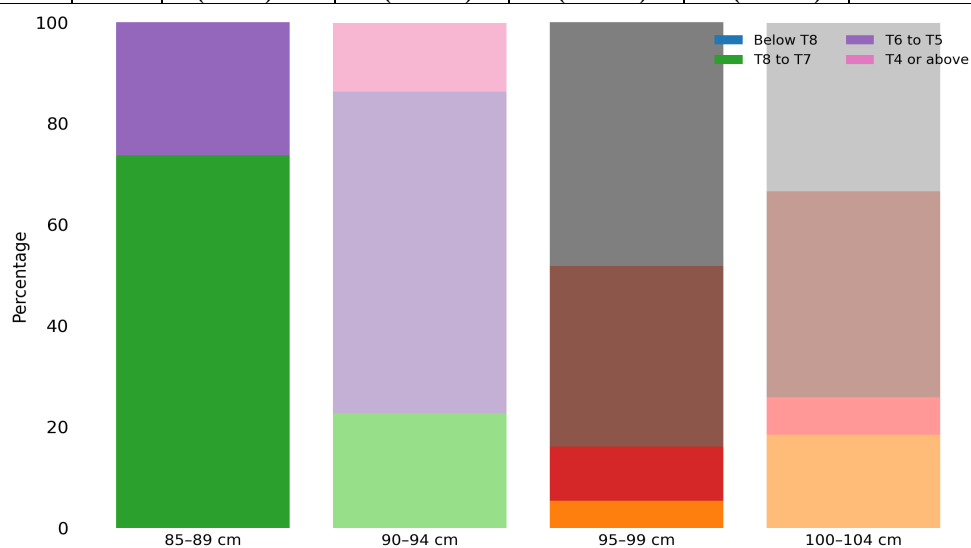


Figure 5: Distribution of highest sensory block level according to abdominal girth category.

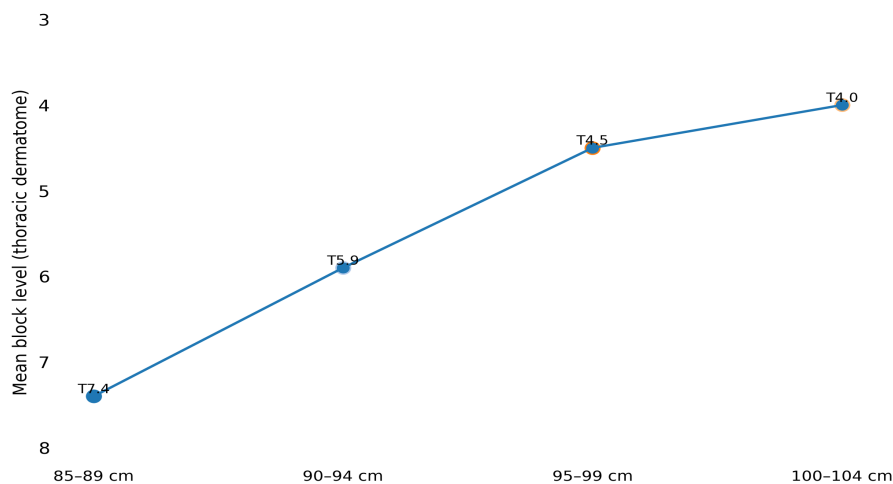


Figure 6: Mean highest sensory block level according to abdominal girth category.

Table 5 demonstrated that increasing abdominal girth was associated with cephalad spread of sensory block. In the 85–89 cm AG group, 14 participants (73.7%) had block levels between T8 and T7, and none reached T4 or above. In the 90–94 cm group, 28 participants (63.6%) had block levels between T6 and T5, and 6 participants (13.6%) reached T4 or

above. In the 95–99 cm group, 27 participants (48.2%) reached T4 or above. In the 100–104 cm group, 9 participants (33.3%) reached T4 or above. The mean block level increased from $T7.4 \pm 0.5$ in the lowest AG group to $T4.0 \pm 1.0$ in the highest AG group. This association was statistically significant with $p < 0.001$.

Table 6: Mean Systolic Blood Pressure (mmHg) at Successive Time Intervals by SFH Category (N = 146)

SFH Category	Baseline	5 min	10 min	15 min	20 min	30 min	p-value
SFH 30–32 cm	118.1 ± 9.4	115.6 ± 8.9	114.2 ± 9.0	116.1 ± 8.5	117.0 ± 8.3	118.4 ± 7.9	p < 0.001
SFH 33–35 cm	118.6 ± 9.1	108.4 ± 9.6	106.2 ± 9.1	109.1 ± 8.8	113.5 ± 8.0	117.2 ± 7.8	
SFH 36–38 cm	117.9 ± 9.6	98.7 ± 10.2	94.2 ± 11.4	96.8 ± 10.6	104.3 ± 9.8	112.6 ± 9.2	
SFH 39–40 cm	119.2 ± 8.8	91.6 ± 12.4	86.4 ± 13.1	88.2 ± 12.8	96.4 ± 11.4	108.8 ± 10.3	

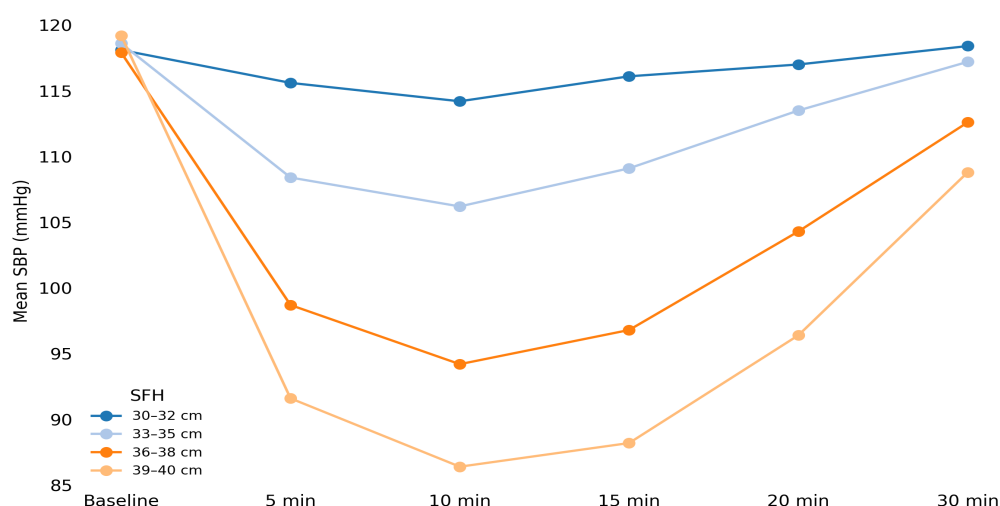


Figure 7: Mean systolic blood pressure at successive time intervals according to symphysiofundal height category.

Table 6 described serial systolic blood pressure changes following spinal anesthesia across SFH

categories. In the 30–32 cm group, systolic blood pressure remained relatively stable, from 118.1 ± 9.4

mmHg at baseline to 114.2 ± 9.0 mmHg at 10 minutes and 118.4 ± 7.9 mmHg at 30 minutes. In the 33–35 cm group, systolic blood pressure decreased from 118.6 ± 9.1 mmHg at baseline to 106.2 ± 9.1 mmHg at 10 minutes, followed by recovery to 117.2 ± 7.8 mmHg at 30 minutes. In the 36–38 cm group, the decline was more pronounced, from 117.9 ± 9.6 mmHg at baseline to 94.2 ± 11.4 mmHg at 10

minutes, with partial recovery to 112.6 ± 9.2 mmHg at 30 minutes. The greatest fall was observed in the 39–40 cm group, where systolic blood pressure decreased from 119.2 ± 8.8 mmHg at baseline to 86.4 ± 13.1 mmHg at 10 minutes and recovered to 108.8 ± 10.3 mmHg at 30 minutes. The changes were statistically significant in all SFH groups, with $p < 0.001$.

Table 7: Post-Operative Recovery Profile by Symphysiofundal Height Category (N = 146)

SFH Cat.	n	Time to First Rescue Analgesia (min) Mean $\pm$ SD	Sensory Regression (min)	Motor Regression (min)	Sensory Block Duration (min)	Motor Block Duration (min)
30–32 cm	22	118.2 ± 9.6	78.4 ± 5.2	84.6 ± 8.8	138.4 ± 18.2	225.6 ± 22.4
33–35 cm	48	118.6 ± 9.0	79.1 ± 5.6	85.2 ± 9.0	141.2 ± 19.6	228.4 ± 24.1
36–38 cm	51	117.9 ± 9.8	79.8 ± 6.1	84.8 ± 9.2	143.6 ± 20.4	231.2 ± 25.6
39–40 cm	25	118.4 ± 9.2	80.2 ± 5.8	85.6 ± 9.6	146.8 ± 21.2	238.4 ± 28.2
p-value	–	0.982	0.817	0.934	0.041	0.038

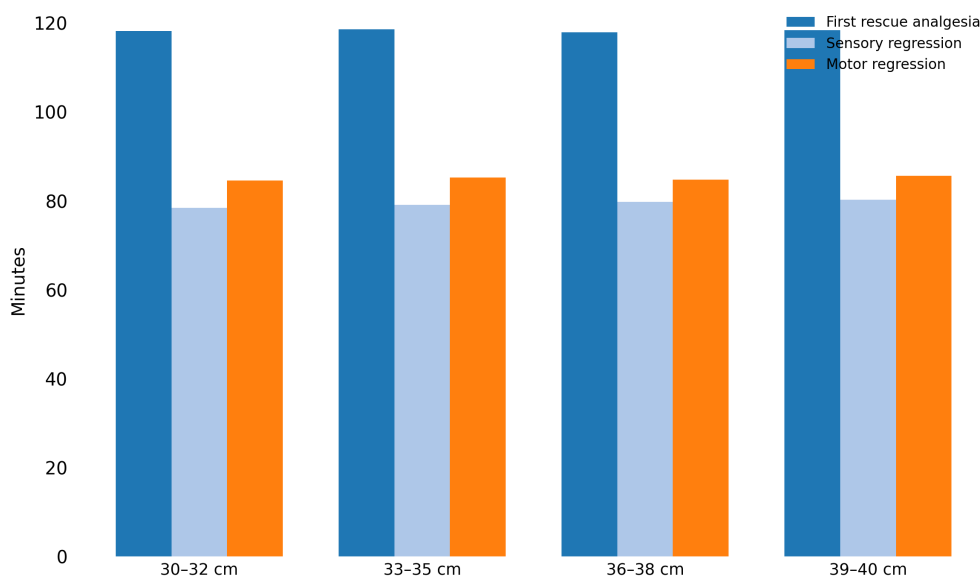


Figure 8: Recovery profile according to symphysiofundal height category.

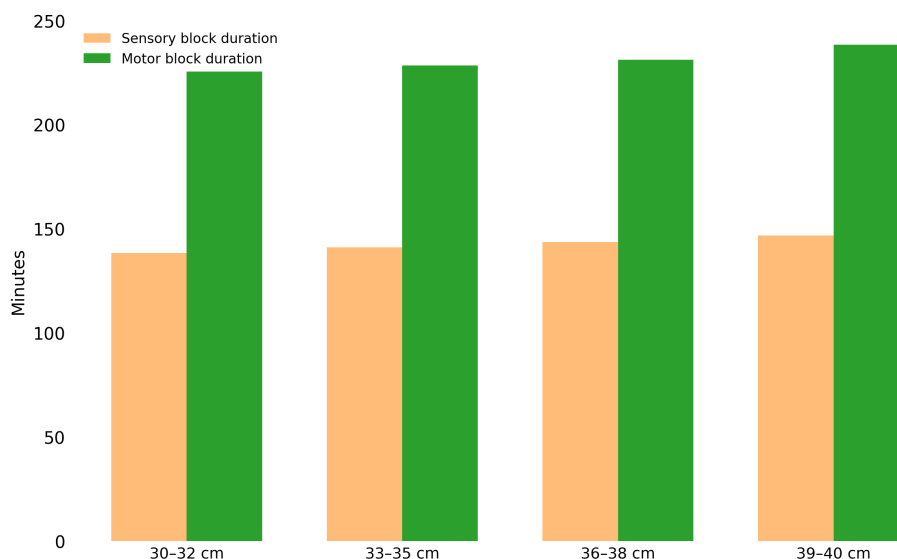


Figure 9: Sensory and motor block duration according to symphysiofundal height category.

Table 7 presented recovery-related parameters across SFH categories. The time to first rescue analgesia was comparable across groups, ranging from 117.9 ± 9.8 minutes to 118.6 ± 9.0 minutes, with no significant difference ($p = 0.982$). Sensory regression time was also comparable, ranging from 78.4 ± 5.2 minutes in the 30–32 cm group to 80.2 ± 5.8 minutes in the 39–40 cm group ($p = 0.817$). Motor regression time remained similar across

groups, ranging from 84.6 ± 8.8 to 85.6 ± 9.6 minutes ($p = 0.934$). However, sensory block duration increased from 138.4 ± 18.2 minutes in the 30–32 cm group to 146.8 ± 21.2 minutes in the 39–40 cm group, showing statistical significance ($p = 0.041$). Motor block duration also increased from 225.6 ± 22.4 minutes to 238.4 ± 28.2 minutes, with a significant p-value of 0.038.

Table 8: Incidence of Anaesthesia-Related Side Effects by SFH Category (N = 146)

SFH Category	Hypotension (n, %)	Nausea Vomiting (n, %)	Shivering (n, %)	Headache (n, %)	Any Complication (n, %)
30–32 cm (n=22)	4 (18.2%)	1 (4.5%)	0 (0.0%)	0 (0.0%)	4 (18.2%)
33–35 cm (n=48)	14 (29.2%)	8 (16.7%)	2 (4.2%)	1 (2.1%)	20 (41.7%)
36–38 cm (n=51)	40 (78.4%)	22 (43.1%)	8 (15.7%)	4 (7.8%)	42 (82.4%)
39–40 cm (n=25)	22 (88.0%)	16 (64.0%)	6 (24.0%)	4 (16.0%)	23 (92.0%)
p-value	< 0.001	< 0.001	0.002	0.011	< 0.001

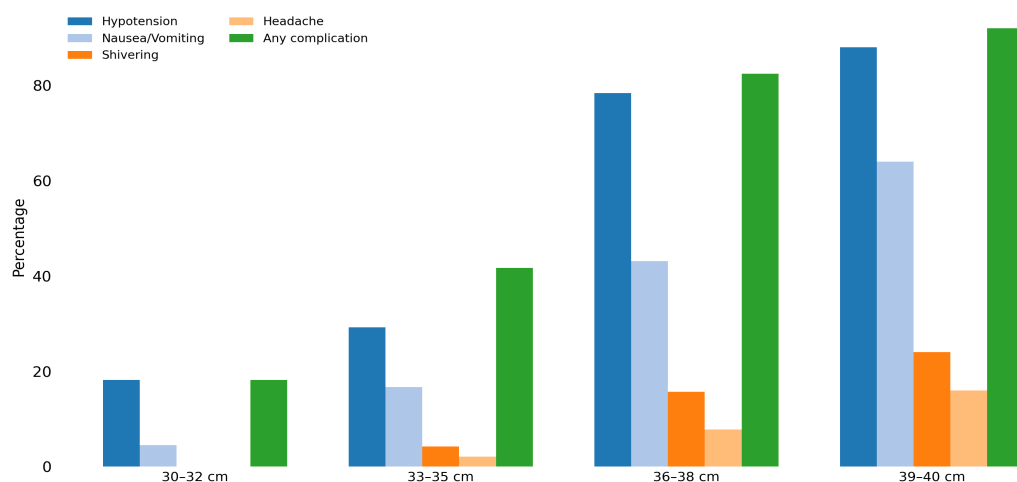


Figure 10: Anaesthesia-related side effects according to symphysiofundal height category.

Table 8 showed that anaesthesia-related complications increased with higher SFH. In the 30–32 cm group, hypotension occurred in 4 participants (18.2%), nausea/vomiting in 1 participant (4.5%), and any complication in 4 participants (18.2%). In the 33–35 cm group, hypotension was seen in 14 participants (29.2%), nausea/vomiting in 8 participants (16.7%), shivering in 2 participants (4.2%), headache in 1 participant (2.1%), and any complication in 20 participants (41.7%). In the 36–38 cm group, hypotension occurred in 40 participants (78.4%), nausea/vomiting in 22 participants (43.1%), shivering in 8 participants (15.7%), headache in 4 participants (7.8%), and any complication in 42 participants (82.4%). The highest complication burden was observed in the 39–40 cm group, where hypotension occurred in 22 participants (88.0%), nausea/vomiting in 16 participants (64.0%), shivering in 6 participants (24.0%), headache in 4 participants (16.0%), and any complication in 23 participants (92.0%). All complications showed statistically significant associations with SFH, including hypotension and

nausea/vomiting with $p < 0.001$, shivering with $p = 0.002$, headache with $p = 0.011$, and any complication with $p < 0.001$.

Discussion

The present prospective observational study was conducted among 146 parturients undergoing caesarean section under spinal anaesthesia with hyperbaric bupivacaine and intrathecal fentanyl at a tertiary care centre. It assessed the effect of symphysiofundal height (SFH) and abdominal girth (AG) on post-spinal hypotension, sensory block spread, haemodynamic profile, vasopressor requirement, recovery characteristics, and anaesthesia-related side effects.

Demographic and Baseline Profile: Participants were predominantly young adults, with 65.7% aged 18–29 years. Mean height was 154.8 ± 5.3 cm, weight 68.4 ± 8.7 kg, and BMI 28.5 ± 3.6 kg/m², placing the population in the overweight category on average. Mean gestational age was 38.6 ± 0.9 weeks and estimated fetal weight 3.01 ± 0.38 kg. Baseline

systolic blood pressure (SBP) was 118.4 ± 9.2 mmHg, diastolic pressure 76.1 ± 7.4 mmHg, mean arterial pressure 90.2 ± 7.8 mmHg, and heart rate 84.3 ± 10.5 bpm, indicating haemodynamic stability.

These characteristics were comparable with Parthasarathy et al. (2019), who reported similar age, weight, and height ranges.[6] Musti (2023) also reported comparable gestational age and baseline vital parameters.[10] Li et al. (2024) identified baseline SBP, heart rate, maternal BMI, multiparity, and fetal weight as independent predictors of more severe post-spinal hypotension.[11] The overweight mean BMI and fetal weight of approximately 3.01 kg may have contributed to background hypotension risk in the present population.

The largest age subgroup comprised 57 participants (39.0%) aged 25–29 years, followed by 39 (26.7%) aged 18–24 years. Baseline oxygen saturation was $99.1 \pm 0.7\%$. The relatively homogeneous baseline profile provided a useful context for examining relationships between obstetric anthropometric measurements and post-spinal haemodynamic responses, although these measurements represent only part of the background risk described in the cited literature.

Distribution of SFH and AG: Mean SFH was 36.1 ± 2.6 cm. The largest category was 36–38 cm, comprising 51 participants (34.9%), followed by 33–35 cm in 48 (32.9%), 39–40 cm in 25 (17.1%), and 30–32 cm in 22 (15.1%). Mean AG was 95.3 ± 5.1 cm; 56 participants (38.4%) had AG 95–99 cm, 44 (30.1%) had 90–94 cm, 27 (18.5%) had 100–104 cm, and 19 (13.0%) had 85–89 cm.

This distribution was consistent with Parthasarathy et al. (2019), who enrolled parturients with SFH 30–40 cm and AG 85–99 cm. [6] Musti (2023) categorised participants into SFH 32–35 cm and 36–39 cm groups. [10] The predominance of larger measurements may partly explain the overall hypotension rate of 54.8%. Larger uterine dimensions are associated with greater aortocaval compression and reduced haemodynamic reserve. Increased intra-abdominal pressure and reduced lumbosacral cerebrospinal fluid (CSF) volume may facilitate greater intrathecal drug spread and sympathetic blockade. [4]

The predominance of SFH values between 33 and 38 cm and AG values between 90 and 99 cm provided a spectrum for evaluating anaesthetic outcomes. At term, the gravid uterus contributes to inferior vena caval compression and changes in the epidural venous plexus. Larger measurements may therefore reflect physiological changes relevant to both haemodynamic reserve and intrathecal anaesthetic distribution. [4]

Incidence and Severity of Hypotension: Post-spinal hypotension occurred in 80 of 146

participants (54.8%). It was defined as a fall in SBP greater than 20% from pre-anaesthetic baseline, consistent with the cited literature. [6,12] The incidence lies within the reported range of 29–80% and is comparable with observations from Indian tertiary care centres using similar anaesthetic protocols.

Hypotension increased progressively with SFH, occurring in 4 participants (18.2%) with SFH 30–32 cm, 14 (29.2%) with 33–35 cm, 40 (78.4%) with 36–38 cm, and 22 (88.0%) with 39–40 cm ($p < 0.001$). The reported mean SBP change increased in magnitude from -0.4 ± 0.6 mmHg in the lowest category to -22.4 ± 6.3 mmHg in the highest, indicating greater haemodynamic disturbance with larger SFH.

Parthasarathy et al. (2019) reported hypotension rates of 16.9% with SFH 30–35 cm and 78.37% with SFH 36–40 cm. [6] The present study demonstrates a similar gradient in a larger sample. Musti (2023) reported corresponding rates of 52.3% and 88.4% in SFH 32–35 cm and 36–39 cm groups. [10]

A similar relationship was observed with AG. Hypotension increased from 5.3% with AG 85–89 cm to 31.8% with 90–94 cm, 75.0% with 95–99 cm, and 85.2% with 100–104 cm ($p < 0.001$). Suryawanshi and Roshni (2024) likewise reported significantly higher hypotension with abdominal circumference greater than 109 cm compared with values below 95 cm. [8]

These findings partially contrast with Thomard et al. (2020), who found greater mean arterial pressure reduction with larger abdominal circumference but no significant difference in dichotomous hypotension incidence. [13] Differences in definitions, sample size, anaesthetic protocols, and circumference thresholds may explain this discrepancy. Greater intra-abdominal pressure, aortocaval compression, and reduced CSF volume provide a plausible physiological explanation for the observed gradient.

The agreement with earlier SFH studies is particularly evident in the marked rise in hypotension among women with measurements of 36 cm or more. Both the frequency of hypotension and the magnitude of pressure reduction increased across categories, indicating that the observed relationship involved incidence as well as severity. The accompanying AG gradient reinforces this pattern within the study population.

Correlations with Hypotension and Sensory Block: SFH showed a moderate-to-strong positive correlation with hypotension incidence (Spearman's $r_s = +0.612$, $p < 0.001$), as did AG ($r_s = +0.648$, $p < 0.001$). Correlations with sensory block level were $+0.578$ for SFH and $+0.603$ for AG (both $p < 0.001$). Ephedrine requirement also correlated positively

with SFH (Pearson's $r = +0.534$) and AG ($r = +0.572$), with $p < 0.001$ for both.

These coefficients exceeded those reported by Parthasarathy et al. (2019), who found correlations of 0.338 for SFH and 0.341 for AG with hypotension incidence. [6] Musti (2023) reported a negative correlation between SFH and SBP ($r = -0.389$), supporting the direction of the present findings. [10]

The association with sensory block level supports the hypothesis that larger uterine dimensions reduce lumbosacral CSF volume and facilitate cephalad spread of intrathecal local anaesthetic. Bhat et al. (2024) described these mechanisms, while She et al. (2021) identified abdominal girth, vertebral column length, and amniotic fluid index as significant determinants of sensory block spread. [4,14] The association with ephedrine requirement suggests that larger measurements accompany both more frequent hypotension and greater treatment requirements.

Yu et al. (2021) concluded that no single conventional demographic predictor consistently demonstrated robust predictive performance for post-spinal hypotension. [12] The present findings suggest that SFH and AG may contribute useful obstetric-specific information to preoperative risk assessment.

Depth and Spread of Spinal Anaesthesia: The highest sensory block level was significantly associated with SFH and AG. In the SFH 30–32 cm group, 72.7% had T8–T7 blocks and none reached T4 or above. Mean block level progressed from $T7.2 \pm 0.5$ in the lowest SFH category to $T3.8 \pm 1.1$ in the highest ($p < 0.001$). Similarly, 73.7% of participants with AG 85–89 cm had T8–T7 blocks, while the highest AG category had a mean block level of $T4.0 \pm 1.0$.

Kim et al. (2021) reported correlations between sensory block level and both BMI and the abdominal circumference-to-height ratio at 5, 10, and 15 minutes after spinal injection. [15] She et al. (2021) found significant associations with vertebral column length ($p < 0.001$), abdominal girth ($p = 0.022$), and amniotic fluid index ($p = 0.022$), whereas height, weight, BMI, and gestational weight gain were not significantly associated. [14]

The present findings support the relationship between larger obstetric anthropometric measurements and greater cephalad block spread. Higher blocks may produce more extensive sympathetic blockade and haemodynamic compromise. The mean level of T3.8 in the highest SFH category approaches the cardioaccelerator fibres at T1–T4, potentially compounding hypotension with bradycardia. Larger SFH and AG therefore warrant increased vigilance and vasopressor preparedness.

Haemodynamic Changes and Vasopressor Requirement:

Serial SBP measurements demonstrated distinct trajectories across SFH categories. In the 30–32 cm group, SBP declined from 118.1 ± 9.4 mmHg at baseline to 114.2 ± 9.0 mmHg at 10 minutes, recovering to 118.4 ± 7.9 mmHg at 30 minutes. The 33–35 cm group reached 106.2 ± 9.1 mmHg at 10 minutes, compared with 94.2 ± 11.4 mmHg in the 36–38 cm group. The 39–40 cm group showed the greatest decline, reaching 86.4 ± 13.1 mmHg before recovering partially to 108.8 ± 10.3 mmHg at 30 minutes ($p < 0.001$).

The greatest haemodynamic vulnerability occurred during the first 10 minutes, particularly with higher SFH. The nadir of 86.4 mmHg represented approximately a 27.5% reduction from baseline. Bhat et al. (2024) similarly emphasised intensive maternal and fetal haemodynamic monitoring during the early post-spinal period. [4]

Vasopressor requirements increased significantly with SFH. Ephedrine was administered to 13.6% of the 30–32 cm group, 70.6% of the 36–38 cm group, and 84.0% of the 39–40 cm group. Corresponding mean doses were 6 ± 0 mg, 9.2 ± 2.4 mg, and 12.6 ± 3.1 mg. Fluid bolus requirements increased from 9.1% in the lowest category to 48.0% in the highest, while mean hypotensive episodes increased from 1.3 ± 0.5 to 3.2 ± 1.4 ($p < 0.001$).

Musti (2023) likewise reported greater ephedrine requirements with higher SFH: 11.05 ± 5.13 mg versus 7.91 ± 2.86 mg ($p < 0.001$). [10] Suryawanshi and Roshni (2024) documented greater requirements with higher abdominal circumference. [8] Singh et al. (2020) described phenylephrine as the preferred vasopressor in non-compromised parturients because of its favourable fetal acid-base profile. [16] Park and Choi (2024) reported effective prophylaxis with phenylephrine and norepinephrine infusions, with norepinephrine providing a more stable heart rate profile. [17]

These findings suggest that SFH ≥ 36 cm or AG ≥ 95 cm should prompt closer blood pressure monitoring during the first 10–15 minutes, early vasopressor availability, adequate co-loading, and left uterine displacement to reduce aortocaval compression.

Recovery and Anaesthesia-Related Side Effects:

Recovery parameters showed a selective association with SFH. Time to first rescue analgesia remained comparable, ranging from 117.9 ± 9.8 to 118.6 ± 9.0 minutes ($p = 0.982$). Sensory regression ranged from 78.4 ± 5.2 to 80.2 ± 5.8 minutes ($p = 0.817$), and motor regression from 84.6 ± 8.8 to 85.6 ± 9.6 minutes ($p = 0.934$).

However, total sensory block duration increased from 138.4 ± 18.2 minutes in the lowest SFH group to 146.8 ± 21.2 minutes in the highest ($p = 0.041$). Motor block duration increased from 225.6 ± 22.4 to

238.4 ± 28.2 minutes ($p = 0.038$). Thus, early recovery endpoints were largely unchanged, although total sensory and motor block durations were modestly prolonged. This may reflect greater cephalad spread and broader neural exposure following intrathecal administration.

Anaesthesia-related side effects demonstrated a marked gradient. In the lowest SFH category, 4 participants (18.2%) experienced complications, including hypotension in 4 (18.2%) and nausea/vomiting in 1 (4.5%), without shivering or headache. In the highest category, 23 participants (92.0%) experienced at least one complication: hypotension in 22 (88.0%), nausea/vomiting in 16 (64.0%), shivering in 6 (24.0%), and headache in 4 (16.0%). Hypotension and nausea/vomiting were significantly more frequent (both $p < 0.001$), as were shivering ($p = 0.002$) and headache ($p = 0.011$).

The association between nausea/vomiting and SFH is likely related to greater hypotension. Increased shivering may reflect more extensive sympathetic blockade and impaired thermoregulatory control. Yu et al. (2021) identified higher sensory block levels as a composite risk factor for haemodynamic and non-haemodynamic complications in obstetric spinal anaesthesia. [12] The increasing side-effect burden supports anticipatory hydration, vasopressor preparedness, attention to thermoregulation, and appropriate patient counselling.

The distinction between unchanged early recovery endpoints and prolonged total block duration is clinically relevant when interpreting the recovery profile. Higher SFH was associated predominantly with intra-operative haemodynamic vulnerability and side-effect burden, together with modest differences in total block duration. These observations support attention to the immediate post-spinal period while recognising that rescue analgesia timing and initial regression measures remained similar across the groups.

Overall Interpretation: Overall, SFH and AG were significantly associated with post-spinal hypotension, sensory block height, ephedrine requirement, and anaesthesia-related side effects. Increasing measurements accompanied greater haemodynamic disturbance and treatment requirements, while early recovery endpoints remained comparable. These observations are biologically plausible and consistent with reports by Parthasarathy et al., Musti, Suryawanshi and Roshni, Bhat et al., and She et al. [4,6,8,10,14]

SFH and AG are simple, non-invasive bedside measurements that may be incorporated into routine pre-anaesthetic assessment. Their use may improve preoperative risk stratification, facilitate early vasopressor preparedness, and support more individualised haemodynamic management of

parturients undergoing caesarean section under spinal anaesthesia. These measurements may therefore help identify parturients requiring closer observation and timely intervention.

Conclusion

This study concluded that symphysiofundal height and abdominal girth were simple, reproducible, and clinically useful bedside predictors of post-spinal hypotension during caesarean section. Increased SFH and AG were associated with a higher risk of hypotension following spinal anaesthesia, suggesting their potential role in preoperative risk assessment. Routine measurement of these parameters may help anaesthesiologists identify high-risk parturients before intrathecal injection. This could allow timely planning of preventive strategies such as left uterine displacement, fluid co-loading, vasopressor preparedness, and closer haemodynamic monitoring. However, as the study was observational and conducted at a single center, the findings should be interpreted with caution. Further prospective multicentric studies are required to validate the proposed cutoff values before their routine use in obstetric anaesthetic practice.

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