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Original Research Article

RELATIONSHIP BETWEEN ABDOMINAL CIRCUMFERENCE AND INCIDENCE OF HYPOTENSION DURING CAESAREAN SECTION UNDER SPINAL ANAESTHESIA

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Abstract

Background: Abdominal circumference (AC) represent the contents within the abdominal cavity, which increase during pregnancy due to factors such as foetal size, amniotic fluid, and uterine growth. A larger AC has been associated with higher intra-abdominal pressure and elevated sensory block levels during spinal anaesthesia. This study uses AC as an indicator for intra-abdominal pressure and hypothesises that increased AC, linked to elevated abdominal pressure and uterine size, correlates with a higher incidence of hypotension during caesarean sections under spinal anaesthesia. Evaluating this relationship between abdominal circumference and the incidence of hypotension during caesarean section is the primary aim of this study. **Materials & Methods:** This double-blind study included 152 ASA Class II parturients, scheduled for elective caesarean sections under spinal anaesthesia. Pre-anaesthetic evaluation involved measuring height, weight, BMI, and AC at the umbilicus in the supine position at the end of inspiration. AC was measured again on the day of surgery, with discrepancies resolved by selecting the lowest value. Spinal anaesthesia was administered using a 25-gauge Quincke needle with 10 mg of 0.5% bupivacaine at the L3-L4 interspace. A T4 block level was required for meeting the inclusion criteria. Vital signs were monitored, with hypotension defined as a systolic blood pressure (SBP) < 90 mmHg or a mean arterial pressure (MAP) < 65 mmHg. Hypotension was treated with intravenous mephentermine, and the dosage was recorded. **Results:** Eighty-one out of 152 participants developed hypotension, with a significantly higher incidence in the larger abdominal circumference (LAC) group (77.80%) compared to the smaller abdominal circumference (SAC) group (22.20%, p = 0.001). Larger AC was significantly associated with higher hypotension incidence, more frequent episodes, and a greater maximum decrease in MAP from baseline. Maternal complications and foetal Appearance, Pulse, Grimace, Activity and Respiration (APGAR) scores were comparable between the groups. **Conclusion:** Abdominal circumference is a relevant predictor of post-spinal hypotension. Larger circumferences indicate a need for closer monitoring and tailored interventions during spinal anaesthesia to mitigate hypotension risk.

INTRODUCTION

Regional anaesthesia using local anaesthetics is the preferred technique for caesarean delivery due to its lower morbidity and mortality compared to general anaesthesia, which carries a higher risk of complications such as difficult intubation, aspiration, and neonatal depression.[1-2] Despite its benefits, regional anaesthesia is not without complications, with hypotension being one of the most common, occurring in 15–33% of the general population and up to 20–100% in obstetric patients.[2] This can lead to serious maternal–foetal consequences, including nausea, vomiting, and foetal hypoxia.

The spread of local anaesthetics intrathecally is influenced by factors such as patient position, height, weight, pregnancy, intra-abdominal pressure (IAP), and lumbosacral cerebrospinal fluid (CSF) volume. AC, which reflects intra-abdominal contents, increases during pregnancy due to foetal size, amniotic fluid volume, and uterine growth.[3] Previous studies have linked larger AC to higher IAP,[4] and sensory block levels.[5] AC was used in this study as a surrogate for abdominal pressure since measuring IAP directly is impractical. Additionally, an enlarged uterus compresses the inferior vena cava, leading to epidural venous plexus engorgement, reduced CSF volume, and narrowed intrathecal space, which can result in a more cephalad spread of spinal anaesthesia and increased hypotension,[6] risk.

This study hypothesises that increased AC, associated with elevated abdominal pressure and uterine size, correlates with a higher incidence of hypotension during caesarean sections under spinal anaesthesia. The primary aim was to assess the relationship between AC and hypotension, while secondary aims included identifying the critical AC above which hypotension increases, comparing vasopressor dosage, and evaluating neonatal outcomes.

MATERIALS AND METHODS

A prospective double blind observational study was done on term pregnant women who met the inclusion criteria of ASA physical status II, aged 18-40 years, with a height range of 150-170 cm and a Body Mass Index (BMI) of less than 30. The exclusion criteria of the study comprised of patients with multiple pregnancies, obesity (BMI > 30), SBP below 100 mmHg, cardiovascular comorbidities, polyhydramnios, high-risk pregnancies (including placenta previa, abruptio placentae, eclampsia, preeclampsia, gestational diabetes), and contraindications to regional anaesthesia. The required sample size, calculated based on a population proportion of 0.94 (94%), sample proportion of 0.88 (88%), with a 5% alpha error and 80% power, was determined to be 152 participants.

Following approval from the institutional ethical committee, informed and written consent was taken from 152 parturients of American Society of Anaesthesiologist Physical Status (ASA-PS) Class II undergoing elective lower segment caesarean section under spinal anaesthesia. A thorough pre-anaesthetic evaluation was conducted on the previous day of the procedure. During this evaluation and also on the day of surgery, the AC of all participants were measured at the level of umbilicus, at the end of inspiration with the patient in supine position. All measurements were conducted by a single operator, and in case of discrepancies, the lowest measurement was recorded as final.

A Double-blind study was conducted by blinding the anaesthetist who performed the spinal anaesthesia and the participant. Standard monitoring including pulse oximetry, non-invasive blood pressure (NIBP) and electrocardiography (ECG) was done with the patient in supine position using a Philips Intellivue MP20/MP30 multiparameter monitor. After confirming the patency of intravenous access, patients were co-loaded with 500 ml crystalloid (Ringer Lactate). Under strict aseptic precautions, lumbar puncture was done with the patient in sitting position at L3 -L4 interspace using 25-gauge Quincke's spinal needle with the midline approach. This was done by the same anaesthetist throughout the study. Each patient received 10 mg of 0.5% heavy bupivacaine intrathecally. Immediately afterward, the patient was put into supine position with a wedge under the right buttock to prevent aortocaval compression. Level of spinal anaesthesia was assessed using a pinprick test every minute for 10 minutes. If a T4 sensory level was not achieved, they were excluded from the study and managed according to institutional protocol.

Fluid management during the perioperative period was titrated by the anaesthesiologist. The SBP, DBP, MAP, and heart rate was recorded at baseline and at every minute for 10 minutes, and later at every 5 minutes after spinal anaesthesia till the end of surgery. Intravenous mephentermine was administered as needed to maintain an MAP of at least 65 mmHg, and the total dosage was recorded. APGAR scores at the first and 5th minute and incidence of adverse events like nausea and vomiting were also recorded. In this study, hypotension was defined as a systolic blood pressure of less than 90 mmHg or a MAP less than 65 mmHg.

Statistical Methods

Nonparametric continuous variables were presented as median and interquartile range (IQR). Categorical variables were presented as number (percentage). $\chi 2$ or Fisher's exact test was used to compare categorical variables. Quantitative variables were compared using the t-test when data was normally distributed and the Mann–Whitney U test when data was non-normally distributed. Repeated-measured Analysis of Variance (ANOVA) was used to determine the changes in MAP over time between larger and smaller AC groups. Spearman's rho was used to test correlations between AC and maximal MAP change from baseline. $p < 0.05$ was considered to denote statistical significance.

RESULTS

The median AC of our study cohort was 102 cm and participants were categorized into two groups: SAC (AC < 102 cm) with 65 participants and LAC (AC ≥ 102 cm) with 87 participants. Demographic

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parameters such as age, height, weight, and BMI were recorded, and comparative analysis was conducted between groups.
The mean age was 26.83 ± 3.31 years in the SAC group and 26.10 ± 3.64 years in the LAC group, with no statistically significant difference between the two groups ($p = 0.21$). In contrast, the mean height was significantly higher in the LAC group (160.68 ± 3.73 cm) compared to the SAC group (152.98 ± 2.59 cm, $p = 0.001$). On comparing the mean BMI (kg/m2), in SAC Group it was found to be 25.40 ± 1.17 and in LAC Group was 26.79 ± 1.34 and this difference was found to be statistically significant with p value 0.001. [Table 1]
The incidence of hypotension was significantly higher in the LAC group (77.80%) compared to the SAC group (22.20%, $p = 0.001$) (Table 2, Figure 1). Additionally, SAC participants experienced fewer episodes of hypotension, with 71.21% having none and 27.27% experiencing one episode, while the LAC group demonstrated a higher frequency, with 35.63% experiencing one episode and 36.79% experiencing severe hypotension (more than one episode), a difference that was statistically significant ($p < 0.001$) based on the Mann-Whitney U-Test.
On comparing the baseline hemodynamic parameters in both the groups, no significant difference was observed with p value > 0.005. [Table 3]
Significant increases in heart rate (HR) were observed in the LAC group at multiple intervals (1, 7, 15, 30, 65, and 90 minutes, $p < 0.05$), likely as a compensatory response to increased hypotension. While no significant differences in SBP were observed between the groups, the LAC group showed a more pronounced decrease at 15 minutes ($p = 0.05$). Additionally, significant declines in diastolic blood pressure (DBP) were noted in the LAC group at various time points (4, 5, 6, 10, 30, 35, 40, and 90 minutes, $p < 0.005$). The LAC group had a greater decrease in MAP at multiple intervals (5, 6, 10, 15, 30, 35, 40 min, $p < 0.05$).
The LAC group experienced a significantly greater maximum decrease in MAP from baseline (23.12 ± 4.12 mmHg) compared to the SAC group (21.85 ± 4.35 mmHg, $p = 0.048$) (Table 4). Additionally, patients in the LAC group required substantially higher doses of mephentermine (mean = 7.24 mg) than those in the SAC group (mean = 1.66 mg, $p < 0.001$) (Table 5). No significant differences in APGAR scores at 1 and 5 minutes were found between the two groups and adverse events were minimal and not statistically significant between groups with $p = 0.356$. [Table 6]

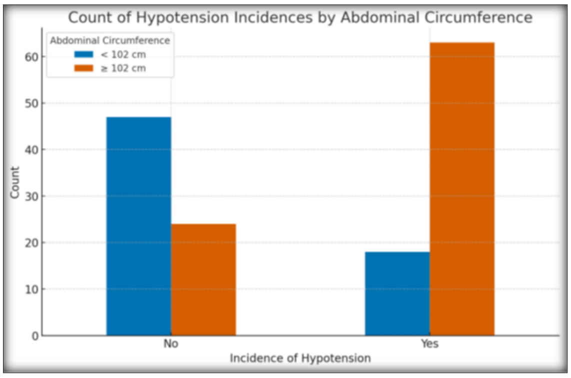

Figure 1: Comparison of Incidence of Hypotension between two groups

Table 1: Demographic profile of patients of both the groups

Demographic Characteristics	Group SAC	Group LAC	p- value
Age (years)	26.83 ± 3.31	26.10 ± 3.64	0.21
Height (cm)	152.98 ± 2.59	160.68 ± 3.73	0.001
BMI (kg/m2)	25.40 ± 1.17	26.79 ± 1.34	0.001

Table 2: Comparison of incidence of hypotension between two groups

Incidence of Hypotension	Group SAC	Group LAC	p- value
Yes (n)	18	63	0.001
No (n)	47	24	

Table 3: Comparison of baseline hemodynamic parameters

Hemodynamic parameter	Group SAC	Group LAC	p- value
Heart rate (bpm)	99.22±5.88	100.54±6.57	0.201
SBP (mm Hg)	121.02±5.67	123.32±4.78	0.007
DBP (mm Hg)	78.52±2.74	78.97±2.15	0.28
MAP (mm Hg)	92.69±3.41	93.75±2.73	0.04

Table 4: Maximum decrease in MAP between two groups

Group	Mean	SD	95% CI	p- value
SAC	21.85	4.35	23.01 – 20.69	0.048
LAC	23.12	4.12	24.24 – 22.00	

Table 5: Comparison of hypotension and mephentermine dosage between two groups

	Group SAC	Group LAC	p- value
Hypotension	22.20%	77.80%	0.001
Mephentermine dosage	1.66	7.24	< 0.001

Table 6: Comparison of APGAR score and adverse events between two groups

Variable		Group SAC	Group LAC	p- value
APGAR at 1 min		8.03±0.49	7.86±0.68	0.14
APGAR at 5 min		8.96±0.18	8.86±0.35	0.083
Adverse events	yes	0	3.45%	0.356
	no	100%	96.55%	

DISCUSSION

This study aimed to explore the relationship between maternal AC and the incidence of post-spinal hypotension. Characteristics such as AC,[7] height, weight8, BMI9, and vertebral column length,[10] are commonly considered during caesarean sections to influence sensory blockade levels and the likelihood of hypotension. Previous research on the association between AC and post-spinal hypotension is limited, with most studies failing to establish a clear link. Moreover, the majority of these studies were conducted outside the Indian population, underscoring the need for research tailored specifically to the Indian context.

A previous study by Hyoojong Kim et al,[11] found a positive correlation between BMI and sensory block levels, and a negative association between height and the level of blockade. Based on these findings, our study included only parturients with a BMI < 30 and height between 150 cm and 170 cm. Abdominal circumference was measured at the umbilical level in the supine position at the end of inspiration. Unlike previous studies, which measured AC in the supine position without accounting for respiratory effects, our study identified 102 cm as the critical abdominal circumference above which the incidence of hypotension was significantly higher.

Our study found a significantly higher incidence of hypotension in the LAC group (p = 0.001). Similar findings were reported by Ahmed et al,[12] where 39 patients (33.6%) out of 116 experienced hypotension, with 31 (50.8%) having an abdominal circumference greater than 101 cm, indicating a linear relationship between larger AC and the degree of hypotension. However, studies by Anadani et al,[13] Thomard et al,[5] and Majid Khan et al,[14] did not observe a significant difference in hypotension incidence between smaller and larger AC groups. This discrepancy may be due to the pre-emptive management of hypotension after spinal anaesthesia, where anaesthesiology teams typically administer intravenous fluid boluses or vasopressors at the first sign of MAP decline or bradycardia, preventing severe hypotension and mitigating its effects.

LAC was significantly associated with a higher frequency of hypotension episodes (p = 0.001). Additionally, the maximum decrease in MAP from baseline was significantly greater in the LAC group (p = 0.048).

Several mechanisms contribute to a pronounced decline in MAP in pregnant women. In late-term pregnancy, the enlarged uterus can cause aortocaval compression, reducing venous return and cardiac output, with LAC correlating with greater MAP decline. Additionally, vena cava compression leads to epidural venous engorgement and narrowed intrathecal space, causing higher cephalad spread of spinal anaesthesia and greater sympathectomy. High abdominal pressure further contributes to increased sensory block levels, elevating the risk of hypotension.

The sample size in our study may have been insufficient to fully capture the actual differences in outcomes between the groups. Additionally, while umbilical cord blood gas analysis is the most reliable indicator of foetal oxygenation and acid-base status, it could not be performed due to financial constraints and ethical considerations. Although abdominal size is positively correlated with abdominal pressure, which has been linked to higher spinal anaesthesia levels and increased hypotension, abdominal pressure was not measured in this study.

CONCLUSION

Our findings affirm a significant association between LAC and hypotension risk during caesarean sections under spinal anaesthesia. With 102 cm identified as a critical threshold, routine AC measurements can modify anaesthesia management strategies, including tailored local anaesthetic dosing and proactive hemodynamic monitoring.

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