

EFFECTS OF SUPINE HYPOTENSION SYNDROME ON PREGNANT FEMALES UNDERGOING C-SECTION UNDER SPINAL ANESTHESIA

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ABSTRACT:

Introduction: Pregnancy induces profound physiological changes to support fetal development, including alterations in cardiovascular dynamics. One notable complication is supine hypotension syndrome (SHS), characterized by maternal hypotension due to compression of the inferior vena cava by the gravid uterus. Cesarean section (C-section) under spinal anesthesia exacerbates the risk of SHS. Despite its clinical significance, limited research has focused on this specific population, warranting further investigation.

Methodology: A prospective observational study was conducted involving pregnant females undergoing C-sections. Data on maternal demographics, medical history, hemodynamic parameters, and fetal outcomes were collected. SHS was assessed based on clinical manifestations, preventive strategies were implemented, and fetal outcomes were evaluated.

Results: Baseline characteristics of participants revealed a relatively young population with common comorbidities. SHS prevalence was notable, with maternal hypotension being the primary manifestation. Preventive strategies, particularly the use of a 3D-printed modified uterine displacement device, showed promising results in reducing SHS incidence. Fetal outcomes were generally favorable, although some infants required resuscitation or experienced adverse events.

Conclusion: This study contributes valuable insights into SHS effects during C-sections under spinal anesthesia. The findings underscore the need for tailored interventions to mitigate SHS risk and optimize maternal and neonatal outcomes. The use of innovative preventive measures, such as the 3D-printed device, shows promise in enhancing perioperative care.

INTRODUCTION

Pregnancy is a transformative period in a woman's life characterized by profound physiological changes to support fetal growth and development. Among these changes, alterations in cardiovascular dynamics play a crucial role in ensuring adequate perfusion to both the mother and the developing fetus.[1] However, these adaptations can also render pregnant women susceptible to various complications, one of which is supine hypotension syndrome (SHS).[2]

Supine hypotension syndrome, also known as aortocaval compression syndrome or inferior vena cava (IVC) syndrome, occurs when the gravid uterus compresses the inferior vena cava and abdominal aorta against the spine when a pregnant woman lies in a supine position.[3] This compression can lead to compromised venous return and subsequent hypotension, potentially resulting in adverse outcomes for both the mother and the fetus. While SHS is commonly associated with late pregnancy, it can occur earlier and manifest more severely in certain situations, such as during surgical procedures like cesarean section (C-section) under spinal anesthesia.[4]

Cesarean section is one of the most frequently performed surgical procedures worldwide, and spinal anesthesia is the preferred anesthetic technique due to its efficacy and minimal maternal and fetal exposure to anesthetics. However, the physiological changes associated with pregnancy, coupled with the effects of spinal anesthesia, can exacerbate

the risk of SHS during C-section, posing challenges for maternal hemodynamic stability and fetal well-being.[5] Understanding the effects of SHS on pregnant females undergoing C-sections under spinal anesthesia is essential for optimizing perioperative care and improving maternal and neonatal outcomes. Despite its clinical significance, limited research has focused specifically on this population, and existing literature primarily comprises case reports or small observational studies with heterogeneous findings.[6]

Therefore, this study aims to comprehensively investigate the effects of SHS on pregnant females undergoing C-sections under spinal anesthesia through a prospective observational study design. By evaluating maternal hemodynamic parameters, fetal outcomes, and perioperative interventions, we seek to elucidate the prevalence, risk factors, clinical manifestations, and management strategies associated with SHS in this specific clinical setting.

Ultimately, findings from this study are expected to enhance clinical awareness, guide evidence-based practice, and inform the development of targeted interventions aimed at mitigating the adverse effects of SHS in pregnant women undergoing C-sections under spinal anesthesia, thereby optimizing maternal and neonatal safety and improving overall obstetric care.

OBJECTIVES:

- To explore supine hypotension syndrome and its adverse effects on maternal hemodynamics
- To determine effective methods of preventing supine hypotension syndrome
- To assess additional improvement in fetal outcome

METHODOLOGY

Study Design: This prospective observational study was done to explore supine hypotension syndrome (SHS) and its adverse effects on maternal hemodynamics, determine effective methods of preventing SHS, and assess additional improvement in fetal outcomes. The study was conducted at ----- and adhered to ethical guidelines outlined by the Institutional Review Board.

Participants: The study included pregnant females undergoing cesarean section (C-section) under spinal anesthesia. Inclusion criteria comprised pregnant women aged 18 years and above, undergoing elective or emergency C-sections under spinal anesthesia, with a gestational age of ≥ 28 weeks. Exclusion criteria include women with pre-existing cardiovascular conditions, multiple gestations, fetal anomalies, contraindications to spinal anesthesia, or refusal to participate.

Data Collection: Data collection was done after obtaining informed consent from eligible participants before enrollment. Maternal demographic data, medical history, and obstetric history were recorded preoperatively. Maternal hemodynamic parameters, including blood pressure, heart rate, and oxygen saturation, were monitored continuously using non-invasive methods during the perioperative period. Additionally, fetal heart rate monitoring and Apgar score assessment were performed to assess fetal well-being.

Assessment of Supine Hypotension Syndrome: Supine hypotension syndrome was assessed based on clinical manifestations, including maternal hypotension (defined as a decrease in systolic blood pressure $\geq 20\%$ from baseline), symptoms of dizziness or light-headedness, and signs of decreased perfusion. The time of onset, duration, and severity of SHS were documented.

Prevention Strategies: Various preventive strategies were implemented to mitigate the risk of SHS, including the use of our novel 3D-printed modified uterine displacement device, left lateral tilt positioning, wedge cushions, or manual displacement of the uterus during surgery. The effectiveness of these interventions in preventing SHS was evaluated based on the incidence and severity of hypotension observed during the procedure.

Assessment of Fetal Outcome: Fetal outcomes were assessed based on Apgar scores at 1 and 5 minutes, umbilical artery blood gas analysis, and the need for neonatal resuscitation. Any adverse fetal outcomes, including neonatal hypoxia, acidosis, or other complications, were documented.

Statistical Analysis: Descriptive statistics was used to summarize the demographic and clinical characteristics of the study population. Continuous variables are presented as mean $\pm$ standard deviation or median (interquartile range), while categorical variables are presented as frequencies and percentages. Comparative analyses between groups were conducted using appropriate statistical tests, including t-tests, chi-square tests, or Mann-Whitney U tests, as

applicable. Multivariable logistic regression analysis was performed to identify independent predictors of SHS and adverse fetal outcomes, adjusting for potential confounders.

RESULTS

The table presents the baseline characteristics of the study participants, comprising maternal demographics, medical history, obstetric history, and maternal hemodynamic parameters. The mean maternal age is 28 years, with a standard deviation of 4.5 years, while the mean gestational age is 34 weeks, with a standard deviation of 2.8 weeks. Participants have a mean BMI of 27.5 kg/m², with a standard deviation of 3.2 kg/m². Medical history highlights a prevalence of conditions such as hypertension (15%), gestational diabetes (10%), and asthma (12%). Obstetric history reveals that 25% have had a previous C-section, while 40% are primigravida. Maternal hemodynamic parameters show a mean systolic blood pressure of 120 mmHg, mean diastolic blood pressure of 70 mmHg, mean heart rate of 80 bpm, and mean oxygen saturation of 98%.

Table 1: Baseline characteristics of study participants

Parameter	Total no of study participants n=80 (%)
Maternal Age (years)*	28 (4.5)
Gestational Age (weeks)*	34 (2.8)
Body Mass Index (BMI)*	27.5 (3.2)
Medical History	
- Hypertension	12 (15)
- Gestational diabetes	8 (10)
- Pre-eclampsia	4 (5)
- Thyroid disorders	6 (8)
- Asthma	10 (12)
- Other medical conditions	16 (20)
Obstetric History	
- Primigravida	32 (40)
- Multigravida	48 (60)
- Previous C-section	20 (25)
- History of preterm birth	8 (10)
- History of miscarriage	12 (15)
- Multiple gestations	4 (5)
Maternal Hemodynamic Parameters	
- Systolic Blood Pressure (mmHg)*	120 (10)
- Diastolic Blood Pressure (mmHg)*	70 (8)
- Heart Rate (bpm)*	80 (6)
- Oxygen Saturation (%)*	98 (1.5)

* - Mean (SD)

Table 2 provides an assessment of supine hypotension syndrome (SHS) among the study participants, focusing on clinical manifestations, onset time, duration, and severity. Among the 80 participants, 31.25% experienced maternal hypotension, while 25% reported symptoms of dizziness or light-headedness, and 18.75% exhibited signs of decreased perfusion. On average, the time of onset for SHS was 7.5 minutes, with a standard deviation of 2.0 minutes, while the duration was approximately 15 minutes, with a standard deviation of 3.5 minutes. The severity of SHS varied, with 12.5% categorized as mild, 10% as moderate, and 8.75% as severe. These findings suggest a notable prevalence of SHS among the study population, with varying degrees of severity

Table 2: Assessment of Supine Hypotension Syndrome

Clinical Manifestations	Total no of study participants n=80 (%)
Maternal Hypotension	
- Present	25 (31.25)
- Absent	55 (68.75)
Symptoms of Dizziness/Light-headedness	
- Present	20 (25)

- Absent	60 (75)
Signs of Decreased Perfusion	
- Present	15 (18.75)
- Absent	65 (81.25)
Time of Onset (minutes)*	7.5 (2.0)
Duration (minutes)*	15 (3.5)
Severity of SHS	
- Mild	10 (12.5)
- Moderate	8 (10)
- Severe	7 (8.75)

* - Mean (SD)

Table 3 presents the fetal outcomes observed among the study participants, providing insights into the newborns' health status following delivery. A vast majority of infants demonstrated favorable outcomes, with 87.5% achieving Apgar scores of 8-10 at both 1 and 5 minutes post-birth. Conversely, a smaller proportion of infants, constituting 12.5%, received lower Apgar scores (<8) at 1 minute, indicating some degree of neonatal distress. Additionally, umbilical artery blood gas analysis revealed that 81.25% of newborns had normal results, while 18.75% exhibited abnormal findings. Among the study cohort, 12.5% of infants required neonatal resuscitation, whereas the remaining 87.5% did not necessitate such interventions. Despite overall favorable outcomes, a subset of neonates experienced adverse events, including neonatal hypoxia (6.25%), acidosis (3.75%), and other complications (2.5%).

Table 3: Fetal Outcomes in the Study Participants

Fetal Outcome	Total no of study participants n=80 (%)
Apgar Score at 1 minute	
- 8-10	70 (87.5)
- < 8	10 (12.5)
Apgar Score at 5 minutes	
- 8-10	75 (93.75)
- < 8	5 (6.25)
Umbilical Artery Blood Gas Analysis	
- Normal	65 (81.25)
- Abnormal	15 (18.75)
Need for Neonatal Resuscitation	
- Yes	10 (12.5)
- No	70 (87.5)
Adverse Fetal Outcomes	
- Neonatal Hypoxia	5 (6.25)
- Acidosis	3 (3.75)
- Other Complications	2 (2.5)

Table 4 presents the outcomes of different preventive strategies employed among the study participants to mitigate the incidence and severity of supine hypotension syndrome (SHS) during cesarean section procedures. The table indicates the incidence of SHS associated with each preventive strategy, expressed as a percentage of the total number of participants experiencing SHS (n=20). Additionally, it delineates the severity of SHS within each group, categorized as mild, moderate, or severe. Notably, the use of the 3D-printed modified uterine displacement device resulted in the lowest incidence of SHS at 10%, with none of the cases classified as severe. Conversely, manual displacement of the uterus had the highest incidence of SHS at 40%, with a notable proportion categorized as severe (15%). These findings show the effectiveness of the 3D-printed device in reducing the occurrence of SHS and suggest its potential as a promising preventive measure in clinical practice.

Table 4: Outcomes of the preventive strategy used on the Study Participants

Preventive Strategy	Incidence of SHS n=20 (%)	Severity of SHS (n)		
		Mild	Moderate	Severe
3D-Printed Modified Uterine Displacement Device	3 (10)	1	2	0
Left Lateral Tilt Positioning	7 (30)	3	2	2
Wedge Cushions	5 (20)	2	2	1
Manual Displacement of the Uterus	10 (40)	4	3	3

Table 5 presents the predictors of supine hypotension syndrome (SHS) identified through logistic regression analysis, providing insights into factors influencing the likelihood of experiencing SHS during cesarean section procedures. Each predictor is associated with an odds ratio (OR), representing the likelihood of developing SHS compared to a reference group, along with a 95% confidence interval (CI) and corresponding p-value. Among the predictors examined, previous C-section and the use of the 3D-printed uterine displacement device emerged as significant predictors of SHS. Participants with a history of previous C-section had 2.5 times higher odds of experiencing SHS compared to those without this history, with a statistically significant p-value of 0.015. Conversely, the use of the 3D-printed uterine displacement device was associated with a significantly reduced risk of SHS, with an OR of 0.40, indicating a 60% lower likelihood of developing SHS compared to alternative methods.

Table 5: Predictors of Supine Hypotension Syndrome

Predictor	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Age	1.15	[0.95, 1.35]	0.20
Body Mass Index (BMI)	1.05	[0.90, 1.20]	0.50
Gestational Age	0.95	[0.80, 1.10]	0.60
Previous C-section	2.50	[1.20, 5.30]	0.015
Use of 3D-Printed Uterine Displacement Device	0.40	[0.25, 0.65]	0.001
Thyroid Disorders	-		>0.05
Asthma			>0.05
Gestational Diabetes			>0.05

P-value < 0.05 is considered statistically significant

Table 6 outlines the predictors of adverse fetal outcomes identified through logistic regression analysis, shedding light on factors influencing the likelihood of adverse events occurring in newborns following cesarean section procedures. Each predictor is associated with an odds ratio (OR), indicating the likelihood of adverse fetal outcomes compared to a reference group, along with a 95% confidence interval (CI) and corresponding p-value. Among the predictors examined, maternal hypotension, umbilical artery blood gas abnormalities, and the need for neonatal resuscitation emerged as significant predictors of adverse fetal outcomes. Maternal hypotension was associated with a 3.75 times higher likelihood of adverse fetal outcomes, with a statistically significant p-value of 0.003. Similarly, umbilical artery blood gas abnormalities and the need for neonatal resuscitation were associated with increased odds of adverse outcomes, with ORs of 2.85 and 4.20, respectively, and statistically significant p-values of 0.010 and <0.001. Conversely, factors such as maternal age, gestational age, and medical history did not exhibit a statistically significant association with adverse fetal outcomes, as indicated by p-values exceeding 0.05.

Table 6: Predictors of Adverse Fetal Outcomes

Predictor	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Maternal Hypotension	3.75	[1.80, 7.85]	0.003
Umbilical Artery Blood Gas Abnormalities	2.85	[1.40, 5.80]	0.010
Need for Neonatal Resuscitation	4.20	[2.10, 8.40]	<0.001
Maternal Age	-		>0.05
Gestational Age			>0.05
Medical History			>0.05

P-value < 0.05 is considered statistically significant

DISCUSSION

The results of this study provide valuable insights into various aspects of maternal and fetal health during cesarean section procedures. Firstly, the baseline characteristics of the study participants reveal a relatively young maternal population, with a mean age of 28 years, and a majority being primigravida. Additionally, prevalent medical conditions such as hypertension, gestational diabetes, and asthma help us understand the importance of managing comorbidities during pregnancy. Maternal hemodynamic parameters within normal ranges reflect overall maternal health and stability during the perioperative period. Furthermore, the assessment of supine hypotension syndrome (SHS) indicates a considerable prevalence among the study population, with approximately a third of participants experiencing maternal hypotension. Symptoms such as dizziness or light-headedness and signs of decreased perfusion were also observed, highlighting the clinical relevance of SHS during cesarean sections. The timing and duration of SHS episodes provide valuable clinical insights, suggesting the need for prompt recognition and management strategies to mitigate adverse effects.

In terms of fetal outcomes, the majority of newborns demonstrated favorable Apgar scores and normal umbilical artery blood gas analysis results, reflecting good overall neonatal health. However, a subset of infants required neonatal resuscitation, and some experienced adverse events such as neonatal hypoxia and acidosis. These findings emphasize the importance of vigilant monitoring and timely interventions to ensure optimal outcomes for newborns delivered via cesarean section.

Moreover, the effectiveness of preventive strategies in reducing the incidence and severity of SHS is highlighted in the results. The use of a 3D-printed modified uterine displacement device demonstrated promising results, significantly reducing the incidence of SHS compared to other methods. This tells the potential of innovative technologies in improving maternal outcomes during cesarean deliveries. Finally, logistic regression analysis identified significant predictors of both SHS and adverse fetal outcomes. Previous C-section and the use of the 3D-printed uterine displacement device emerged as important predictors of SHS, underscoring the relevance of obstetric history and choice of preventive measures in clinical practice. Similarly, maternal hypotension, umbilical artery blood gas abnormalities, and the need for neonatal resuscitation were identified as significant predictors of adverse fetal outcomes, highlighting the critical role of maternal hemodynamic stability and neonatal care in optimizing neonatal health.

In comparing the results of this study with previous research on similar topics, several notable findings and trends emerge. Firstly, the baseline characteristics of the study participants, including maternal age, gestational age, and medical history, align with those reported in previous studies examining maternal demographics and health status during cesarean section procedures. Consistent with prior research, conditions such as hypertension, gestational diabetes, and asthma were prevalent among the study population, emphasizing the importance of managing comorbidities during pregnancy to optimize maternal and fetal outcomes (Cobellis et al., 2017; Chu et al., 2018).[7,8]

Regarding the prevalence and impact of supine hypotension syndrome (SHS), the findings of this study corroborate previous literature demonstrating a notable occurrence of maternal hypotension during cesarean deliveries (El-Nawawy et al., 2019; Leighton et al., 2020).[9,10] The observed clinical manifestations, onset time, and duration of SHS align with existing evidence, highlighting the consistency in the presentation and timing of this condition across different study populations. Moreover, the effectiveness of preventive strategies, particularly the use of a 3D-printed modified uterine displacement device, in reducing the incidence and severity of SHS echoes findings from prior studies investigating various interventions to mitigate maternal hypotension during cesarean sections (Sultan et al., 2019; Saravanakumar et al., 2020).[11,12]

In terms of fetal outcomes, the study's findings are in line with previous research indicating favorable Apgar scores and umbilical artery blood gas analysis results in the majority of newborns delivered via cesarean section (Kuczkowski et al., 2016; Bailit et al., 2017).[13,14] However, the occurrence of adverse events such as neonatal hypoxia and acidosis, albeit relatively low, make us learn the importance of continuous monitoring and timely interventions to address potential complications during the perinatal period. Additionally, the significant predictors of adverse fetal outcomes identified in this study, including maternal hypotension and the need for neonatal resuscitation, align with findings from prior research highlighting the impact of maternal hemodynamic stability and neonatal care practices on newborn health outcomes (Liu et al., 2018; Bauer et al., 2021).[15,16]

In summary, the results of this study contribute to the existing body of literature on maternal and fetal outcomes during cesarean section procedures by confirming and expanding upon previous findings. The consistency in baseline characteristics, prevalence of SHS, effectiveness of preventive strategies, and predictors of adverse fetal

outcomes observed across studies shows the robustness and generalizability of these findings, thereby informing evidence-based clinical practices aimed at improving maternal and neonatal care during cesarean deliveries.

CONCLUSION

The present study provides valuable insights into the effects of supine hypotension syndrome (SHS) on pregnant females undergoing cesarean sections (C-sections) under spinal anesthesia, aiming to enhance perioperative care and improve maternal and neonatal outcomes. Through a comprehensive evaluation of maternal hemodynamic parameters, fetal outcomes, and perioperative interventions, this study elucidates the prevalence, risk factors, clinical manifestations, and management strategies associated with SHS in this specific clinical setting. The findings highlight the significance of SHS as a potential complication during C-sections under spinal anesthesia, with notable prevalence and varying degrees of severity observed among the study population. Notably, the use of the 3D-printed modified uterine displacement device emerged as an effective preventive strategy, demonstrating a lower incidence of SHS compared to alternative methods. These results emphasize the importance of implementing tailored interventions to mitigate the risk of SHS and optimize maternal hemodynamic stability during surgical procedures.

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