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Effects of Pregnancy-Related Changes on Spinal Anaesthesia: A Review Article

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Abstract

Pregnancy produces substantial anatomical, physiological, and pharmacological changes that influence the onset, spread, intensity, and duration of spinal anesthesia. These changes are particularly important during cesarean delivery, where spinal anesthesia is widely used because it provides rapid, reliable surgical anesthesia while allowing the mother to remain conscious during childbirth. The principal pregnancy-related mechanisms include increased intra-abdominal pressure, engorgement of the epidural venous plexus, reduction in cerebrospinal fluid (CSF) volume in the lumbosacral region, alterations in spinal curvature and positioning, increased sensitivity to local anesthetics, and changes in cardiovascular and respiratory physiology. These factors contribute to the higher cephalad spread of intrathecal local anesthetics and the increased susceptibility of pregnant women to spinal-induced hypotension. Pregnancy also influences the technical performance of spinal anesthesia, the choice of drug dosage, maternal hemodynamic stability, and fetal well-being. Understanding these changes is essential for optimizing anesthetic management, preventing complications, and improving maternal and neonatal outcomes. This review discusses the anatomical, physiological, pharmacological, and clinical effects of pregnancy on spinal anesthesia, with particular emphasis on cesarean delivery and evidence-based anesthetic management.

Keywords: Pregnancy; spinal anesthesia; cesarean section; cerebrospinal fluid; local anesthetics; spinal-induced hypotension; maternal physiology; obstetric anesthesia.

Introduction

Spinal anesthesia is one of the most commonly used anesthetic techniques for elective and many emergency cesarean deliveries. It produces a rapid, dense sensory and motor block through the injection of local anesthetic, often combined with an intrathecal opioid, into the subarachnoid space. Compared with general anesthesia, it avoids airway instrumentation and reduces the risks associated with difficult or failed tracheal intubation in pregnant women. Nevertheless, pregnancy changes the anatomy of the vertebral column, the distribution of cerebrospinal fluid, cardiovascular function, respiratory mechanics, and the response to neuraxial drugs. Consequently, a dose that produces a predictable block in a nonpregnant woman may produce a higher or more intense block during pregnancy **[1–5].**

The effects of pregnancy on spinal anesthesia become particularly important during late gestation and cesarean delivery. A successful technique must provide an adequate sensory level, generally around the T4 dermatome for cesarean surgery, while minimizing maternal hypotension, nausea, vomiting, respiratory compromise, and fetal exposure to the consequences of maternal circulatory instability. The anesthesiologist must therefore understand both the mechanisms responsible for the altered spinal block and the strategies used to maintain maternal and uteroplacental perfusion **[6–8]**.

The purpose of this review is to explain how pregnancy modifies the anatomical and physiological conditions under which spinal anesthesia is administered, how these changes influence anesthetic pharmacodynamics and clinical outcomes, and how anesthetic practice can be adapted to improve safety.

Pregnancy-related anatomical changes and their effects on spinal anesthesia (Table 1):

1. Epidural venous engorgement with compression of the dural sac.

During pregnancy, the enlarging uterus increases intra-abdominal pressure and may compress the inferior vena cava, particularly when the mother lies supine. This impedes venous return from the lower body and promotes collateral venous drainage through the vertebral venous plexus. The resulting epidural venous engorgement reduces the available epidural space and contributes to compression of the dural sac. These changes influence the distribution of neuraxial drugs and help explain why pregnant women are more sensitive to spinal and epidural local anesthetics. The effects become increasingly relevant during the second and third trimesters **[9,10].**

2. Reduction in lumbosacral cerebrospinal fluid volume

One of the most important anatomical changes affecting spinal anesthesia is the reduction in lumbosacral CSF volume. In a magnetic resonance imaging study of 18 women examined in both nonpregnant and late-pregnancy states, mean lumbosacral CSF volume decreased from approximately 39.6 mL to 33.2 mL during pregnancy, a reduction of about 16.7%. The reduction was associated with compression of the dural sac and was greater at more advanced gestational ages within the studied range **[11].**

A smaller CSF volume means that a given intrathecal dose of local anesthetic is distributed within a relatively reduced fluid compartment. This may increase the effective concentration of the drug around neural structures and facilitate cephalad spread. However, CSF volume is not the only determinant of block height; other factors include baricity, injection technique, patient position, spinal anatomy, and the physical characteristics of the injected solution. Therefore, the relationship between pregnancy and block height is multifactorial rather than dependent on a single anatomical mechanism **[11–13].**

3. Reduction of both epidural and subarachnoid spaces

Pregnancy-related venous engorgement and increased abdominal pressure may reduce the available space within the vertebral canal. In the epidural space, this can alter the distribution of injected solutions and increase the spread of epidural local anesthetics. In the subarachnoid space, compression of the dural sac and reduced CSF volume can contribute to a more extensive spinal block. Although these mechanisms overlap, the epidural and intrathecal spaces are distinct compartments, and changes in one should not automatically be assumed to produce identical effects in the other **[11,14].**

4. Lumbar lordosis and ligamentous laxity

The enlarging uterus shifts the maternal center of gravity anteriorly, commonly increasing lumbar lordosis and altering the mechanical demands placed on the lumbar spine. Ligamentous laxity, body habitus and soft-tissue changes may also affect positioning. As a result, obtaining a comfortable sitting or lateral position and identifying the appropriate intervertebral space may become more difficult, especially in women with obesity, edema, or pre-existing spinal abnormalities. Lumbar flexion, appropriate positioning, careful landmark identification, and ultrasound assistance when indicated may improve procedural conditions **[15,16].**

Table (1): Major pregnancy-related anatomical changes and their effects on spinal anesthesia **[11–16].**

Pregnancy-related anatomical changes	**Mechanism**	**Effects on spinal anaesthesia**
Epidural venous engorgement	Increased abdominal pressure and altered venous return	Reduced epidural space and altered neuraxial drug distribution

Reduced lumbosacral CSF volume	Dural sac compression associated with venous engorgement	May increase cephalad spread of intrathecal local anesthetic
Increased lumbar lordosis	Anterior shift in the center of gravity and postural adaptation	May influence positioning and the spread of hyperbaric solutions
Changes in soft tissues and body habitus	Weight gain and variable edema	May make anatomical landmarks harder to identify
Altered spinal-space geometry	Combined vascular engorgement, reduced lumbosacral CSF volume, and increased lumbar lordosis lead to reduction of spinal canal diameter and cross sectional area	Greater block height and intensity

Pregnancy-related physiological changes and their effects on spinal anesthesia (Table 2):

1. Cardiovascular changes:

a. Supine hypotensive syndrome:

Pregnancy produces major cardiovascular adaptations, including increased blood volume, increased cardiac output, reduced systemic vascular resistance, and changes in autonomic cardiovascular regulation. During late pregnancy, the supine uterus may compress the inferior vena cava and, to a lesser degree, the aorta, reducing venous return and potentially causing supine hypotensive symptoms. These effects can coexist with the sympathetic blockade produced by spinal anesthesia, increasing the likelihood of clinically important hypotension **[17,18].**

Spinal anesthesia blocks sympathetic outflow below the level of the block. The resulting arterial and venous vasodilation decreases systemic vascular resistance and venous return. In pregnant women, this may produce a rapid reduction in blood pressure, particularly when a high sensory block is established or aortocaval compression is present. Maternal hypotension can cause nausea, vomiting, dizziness, reduced consciousness, and, in severe cases, cardiovascular collapse. Prompt recognition and treatment are essential **[18,19].**

b. Reduction of utero-placental perfusion and compromising of fetal oxygen delivery.

Uteroplacental blood flow depends substantially on maternal perfusion pressure because the uteroplacental circulation has limited capacity for autoregulation. A significant reduction in maternal arterial pressure may therefore reduce placental perfusion and compromise fetal oxygen delivery. The clinical consequences depend on the magnitude and duration of hypotension, the baseline placental reserve, gestational conditions, and the speed of treatment. Maternal hypotension is associated with adverse maternal symptoms and can contribute to fetal acidemia, particularly when hypotension is severe or prolonged **[20].**

Maintaining maternal blood pressure close to its baseline value is consequently a major objective during spinal anesthesia for cesarean delivery. Current guidance supports prophylactic vasopressor administration, intravenous crystalloid co-loading, and left uterine displacement or an appropriate alternative to reduce aortocaval compression. Phenylephrine is widely recommended for prevention and treatment of spinal-induced hypotension in uncomplicated pregnancies, while norepinephrine is an increasingly studied alternative in appropriate settings **[7,21].**

2. Respiratory changes (Increased oxygen consumption; reduced functional residual capacity):

Pregnancy increases oxygen consumption and minute ventilation, largely through increased tidal volume. At the same time, functional residual capacity decreases as the uterus elevates the diaphragm, particularly in late pregnancy. These changes reduce the respiratory reserve available during apnea and can accelerate oxygen desaturation if ventilation becomes inadequate **[22].**

Spinal anesthesia generally preserves consciousness and spontaneous breathing, but a high or total spinal block may impair intercostal muscle function and, in severe cases, diaphragmatic function. Respiratory difficulty may also occur secondary to hypotension, reduced cerebral perfusion, or profound bradycardia. The combination of pregnancy-related reduction in oxygen reserve and a rapidly ascending block makes early assessment of respiratory effort, speech, upper-limb strength, oxygen saturation, and consciousness particularly important **[22, 23].**

3. Gastrointestinal changes (Gastro-esophageal reflux):

Pregnancy is associated with reduced lower esophageal sphincter tone and increased intra-abdominal pressure, contributing to gastroesophageal reflux. These changes are especially important if spinal anesthesia is inadequate, a high block develops, or conversion to general anesthesia becomes necessary. Neuraxial anesthesia reduces the need for airway instrumentation but does not eliminate the need for preparedness to manage aspiration risk and a potentially difficult obstetric airway **[23,24].**

4. Renal, hematological, and fluid-balance changes

Pregnancy increases renal blood flow and glomerular filtration rate, alters plasma volume, and produces physiological changes in coagulation. These changes affect fluid management and the assessment of maternal volume status. However, a healthy pregnant woman with an expanded plasma volume should not be assumed to be protected against spinal-induced hypotension: sympathetic blockade can cause marked venous pooling and a reduction in effective venous return despite increased total blood volume **[25].**

Pregnancy is also a hypercoagulable state, but this does not remove the importance of evaluating thrombocytopenia, hypertensive disorders, anticoagulant use, and other bleeding risks before neuraxial procedures. In particular, platelet count, platelet trend, underlying diagnosis, bleeding history, and the timing of antithrombotic medication must be considered together when assessing neuraxial safety. **[26,27]**

Table 2. Pregnancy-related physiological changes and their effects on spinal anesthesia **[22- 27].**

Pregnancy-related physiological changes	**Principal changes**	**Effects on spinal anesthesia**
Cardiovascular changes	Increased blood volume and cardiac output; reduced systemic vascular resistance	Sympathetic blockade may cause clinically important hypotension
Venous circulation changes	Aortocaval compression, particularly supine	Reduced venous return and increased hypotension risk
Respiratory changes	Increased oxygen consumption; reduced functional residual capacity	Faster desaturation if ventilation is impaired
Gastrointestinal changes	Increased reflux tendency and intra-abdominal pressure	Aspiration precautions remain necessary if conversion to general anesthesia is required
Renal and fluid balance changes	Increased glomerular filtration and altered fluid distribution	Fluid management must be individualized

Hematological changes	Hypercoagulability; possible pregnancy-associated thrombocytopenia	Requires assessment of thrombotic risk and neuraxial bleeding risk

Pregnancy-related-changes and other factors that affects the pharmacology of the used local anaestheic in spinal anaesthesia (Table 3):

1. Increased sensitivity to local anesthetics

Pregnant women generally require less local anesthetic for neuraxial anesthesia than nonpregnant women to achieve a comparable block under otherwise similar conditions. The reasons are incompletely explained and include anatomical changes, reduced CSF volume, possible alterations in neural sensitivity, and hormonal influences. Progesterone and other pregnancy-related neurophysiological changes have been proposed as contributors, although their individual clinical effects remain difficult to isolate **[12,13].**

The practical implication is that intrathecal drug selection and dosing should reflect the intended operation, the urgency of delivery, maternal characteristics, and the need for a reliable surgical block. Excessive dose reduction may lead to an inadequate block and the need for supplemental anesthesia or conversion to general anesthesia, whereas excessive dosing may increase the risk of a high spinal block and severe hemodynamic disturbance. Dose selection should therefore follow established obstetric anesthesia practice rather than a fixed percentage reduction applied to every patient **[14, 28].**

2. Baricity, position, and spread of intrathecal drugs

The distribution of intrathecal local anesthetic depends on solution baricity relative to CSF, patient position during and after injection, dose, volume, injection characteristics, and spinal anatomy. Hyperbaric bupivacaine is commonly used for cesarean delivery. Its distribution is influenced by gravity, making positioning particularly important during the early phase after injection. Pregnancy-related anatomical changes modify the environment in which this distribution occurs, but they do not eliminate the importance of baricity and positioning **[14, 28].**

The block should be assessed repeatedly after injection because the sensory level may continue to rise. A rapid or unexpectedly high block requires immediate evaluation of blood pressure, heart rate, respiratory function, and consciousness. The final sensory level and the adequacy of surgical anesthesia should be confirmed before incision, while recognizing that an initially acceptable level does not guarantee that the block will remain stable throughout surgery **[18, 28].**

3. Intrathecal opioids and adjuncts

Intrathecal opioids, including fentanyl and morphine, are commonly combined with local anesthetics to improve intraoperative comfort and prolong postoperative analgesia. Pregnancy itself does not establish a single optimal opioid dose. The choice depends on the intended duration of analgesia, maternal comorbidities, drug availability, and the potential for pruritus, nausea, vomiting, and respiratory depression. Long-acting neuraxial opioids require appropriate postoperative monitoring according to the drug, dose, and maternal risk factors **[2, 29 –31].**

Other intrathecal adjuncts have been investigated to improve the quality or duration of spinal anesthesia. Their benefits must be balanced against adverse effects and the quality of evidence supporting their use. The presence of pregnancy-related sensitivity to neuraxial drugs makes careful dose selection and clinical monitoring important, but it does not justify assuming that every adjunct has the same dose-response relationship or safety profile in pregnant and nonpregnant patients **[28 – 31].**

Table (3): Pregnancy-related-changes and other factors that affects the pharmacology of the used local anaestheic in spinal anaesthesia **[28-31].**

Pregnancy-related-changes	**Effects on the pharmacology of the used local anaestheic in spinal anaesthesia**	**Managements**
Reduced CSF volume	May facilitate greater spread of intrathecal drug	Avoid assuming that a nonpregnant dose will have identical effects
Increased neuraxial sensitivity	Often associated with a lower local-anesthetic requirement	Individualize dosing while maintaining adequate surgical anesthesia
Baricity of local anesthetic	Influences distribution under gravity	Consider the solution's characteristics and maternal position
Patient positioning	Can influence early intrathecal drug distribution	Use appropriate positioning and reassess block progression
Intrathecal opioids and adjuncts	Improve intraoperative comfort or prolong analgesia, depending on the agent	Select dose and postoperative monitoring according to the opioid used

Effects of pregnancy on the incidence of spinal block complications and the recommended preventive or curative management strategies:

1. Increased incidence of spinal-induced hypotension and bradycardia

Spinal-induced hypotension is one of the most frequent complications of spinal anesthesia for cesarean delivery. The combination of sympathetic blockade, pregnancy-related cardiovascular adaptations, reduced venous return, and aortocaval compression makes prevention particularly important. Clinical manifestations range from mild nausea and dizziness to profound hypotension, bradycardia, altered consciousness, and cardiovascular collapse. The severity of these effects depends on the height of the block, the speed of its development, maternal baseline physiology, and the effectiveness of preventive measures **[18,19].**

A contemporary approach is to start a prophylactic vasopressor infusion immediately after intrathecal injection, titrating it to maternal blood pressure and heart rate. Phenylephrine is an established first-line option in uncomplicated pregnancies; norepinephrine may be suitable in protocols with appropriate expertise and monitoring. Crystalloid co-loading and left uterine displacement complement vasopressor treatment. Current NICE guidance recommends maintaining maternal blood pressure at 90% or more of baseline and avoiding decreases below 80% of baseline during cesarean delivery under spinal anesthesia **[6–8,21].**

2. Higher or unexpectedly extensive spinal block

A higher-than-expected sensory block can occur because pregnancy changes CSF volume and the anatomy of the spinal canal. A high block may produce extensive sympathetic blockade, hypotension, bradycardia, upper-limb weakness, difficulty speaking, respiratory impairment, and loss of consciousness. A total spinal block is a life-threatening emergency that requires immediate airway and circulatory support. **[18, 23].**

The risk cannot be predicted accurately from gestational age alone. Anesthetic dose, baricity, injection site, patient position, spinal anatomy, and individual variation remain important. Therefore, careful dose selection and frequent assessment of the sensory level, blood pressure, heart rate, respiratory status, and consciousness are essential after injection. The team should be prepared to support ventilation and circulation if the block rises excessively **[18, 28].**

3. Increase incidence of failed or inadequate spinal block

Weight gain, lumbar lordosis, and reduced interspinous access may make spinal needle insertion more difficult in some pregnant women with higher incidence of failed or inadequate spinal block.. Obesity and edema may further obscure anatomical landmarks. Multiple attempts can increase patient discomfort and may contribute to traumatic needle placement. Adequate positioning, experienced assistance, appropriate needle selection, and preprocedural ultrasound in selected patients may improve the likelihood of successful placement

Before surgery proceeds, the anesthetist should confirm an adequate bilateral sensory level and motor block, assess the block's suitability for the planned procedure, and have a clear plan for managing inadequate anesthesia. **[16, 32, 33].**

5. Increased incidence of maternal nausea and vomiting

Nausea and vomiting during cesarean delivery under spinal anesthesia frequently accompany hypotension. Reduced cerebral perfusion and changes in autonomic activity are important contributors, although uterine manipulation, visceral traction, and uterotonic medications can also cause symptoms. Prompt correction of hypotension is therefore central to management; antiemetic medication may be added when indicated **[19, 34].**

6. Difficult needle placement

Pregnancy-related anatomical changes, including lumbar lordosis, increased soft-tissue thickness in some patients, and difficulty identifying anatomical landmarks, may make positioning and needle placement more challenging **[21, 35].**

5. Neuraxial hematoma

Spinal or epidural hematoma is a rare but potentially devastating complication because blood accumulating in the spinal canal can compress neural structures. Pregnancy may be accompanied by thrombocytopenia, particularly gestational thrombocytopenia, and certain obstetric disorders, including preeclampsia and HELLP syndrome, may be associated with impaired hemostasis. Anticoagulant treatment and other coagulation abnormalities can further influence risk. Pregnancy alone is not a contraindication to spinal anesthesia. The decision to proceed should consider the platelet count and its trend, the underlying cause of thrombocytopenia, coagulation status, and any antithrombotic medication. Severe back pain, progressive motor weakness, sensory loss, or new bladder or bowel dysfunction after neuraxial anesthesia requires urgent investigation and specialist assessment. **[26, 35**].

7. Fetal academia

The neonatal consequences of spinal anesthesia are often indirect, arising from maternal hemodynamic changes rather than substantial direct exposure to intrathecal drugs. Severe or prolonged maternal hypotension may impair uteroplacental perfusion and contribute to fetal acidemia. Conversely, maintaining maternal blood pressure close to baseline, ensuring adequate oxygenation, and treating bradycardia and hypotension promptly help protect both mother and baby **[6–8,20].**

Spinal anesthesia generally permits the mother to remain awake and avoids the airway risks associated with general anesthesia. However, the anesthetic technique must be individualized according to urgency, maternal comorbidities, coagulation status, fetal condition, and the anticipated duration of surgery. An inadequate block, major hemorrhage, severe fetal compromise, or another urgent clinical problem may require an alternative anesthetic strategy **[21, 24, 28].**

Table (4): Effects of pregnancy on the incidence of spinal block complications and the recommended preventive or curative management strategies **[21, 26, 27, 32].**

Complication	**Pregnancy-related contribution**	**Preventive or curative management** strategies
Hypotension	Sympathetic blockade combined with	Prophylactic vasopressor, crystalloid co-

	aortocaval compression	loading, uterine displacement
Bradycardia	Reduced venous return and extensive sympathetic blockade; may accompany vasopressor treatment	Assess blood pressure and perfusion; treat clinically significant bradycardia promptly
High spinal block	Variable intrathecal spread in a pregnancy-altered spinal environment	Appropriate dosing, repeated block assessment, readiness for airway and circulatory support
Nausea and vomiting	Often related to hypotension; also visceral traction and medications	Correct hypotension and administer antiemetics when indicated
Difficult needle placement	Altered landmarks, obesity, edema, or spinal anatomy	Optimize positioning; consider ultrasound assistance
Neuraxial hematoma	Relevant when thrombocytopenia or coagulation abnormalities are present	Individualized assessment of platelet count, trend, diagnosis, and medication history
Fetal acidemia	May result from significant or prolonged maternal hypotension	Maintain maternal perfusion and treat hemodynamic disturbances rapidly

Effects of specific pregnancy-related conditions on spinal anaesthesia

1. Preeclampsia

Preeclampsia introduces additional cardiovascular, vascular, and hematological considerations. Women with preeclampsia may have altered intravascular volume, increased vascular resistance, endothelial dysfunction, and thrombocytopenia or other coagulation abnormalities. Despite these concerns, spinal anesthesia can be appropriate in selected women with preeclampsia, and it should not automatically be avoided solely because of the diagnosis. The decision requires assessment of blood pressure, severity of disease, platelet count and trend when indicated, coagulation concerns, and the urgency of delivery. **[26, 27, 36**]

Women with severe preeclampsia may have a different hemodynamic response from healthy parturients, and vasopressor requirements can differ. Close monitoring and individualized management are important, particularly when hypertension, reduced organ perfusion, or fetal compromise is present. Neuraxial safety must be assessed in the full clinical context rather than from a single laboratory value alone. **[26, 27, 36]**

2. Obesity

Obesity is associated with increased technical difficulty during neuraxial procedures because landmarks may be less palpable and the distance from the skin to the epidural or subarachnoid space may be greater. It may also coexist with obstructive sleep apnea, hypertension, diabetes, and other conditions that influence anesthetic planning. Neuraxial ultrasound and early anaesthetic assessment may be particularly helpful when difficult placement is anticipated**. [16,37]**

3. Multiple pregnancy

Twin and higher-order pregnancies may be associated with greater uterine size and more pronounced aortocaval compression, although the actual effect varies with gestational age, fetal positions, and maternal anatomy. Spinal anesthesia remains an option for cesarean delivery, but attention to maternal positioning, blood pressure control, and the possibility of prolonged or more complex surgery is important. Evidence does not support a universal spinal dose adjustment based on multiple pregnancy alone. **[17, 28]**

4. Thrombocytopenia and coagulation disorders

Thrombocytopenia can occur in gestational thrombocytopenia, preeclampsia, HELLP syndrome, immune thrombocytopenia, and other conditions. The decision to perform spinal anesthesia must balance the risk of neuraxial hematoma against the risks of alternative anesthetic techniques. A multidisciplinary consensus statement from the Society for Obstetric Anesthesia and Perinatology indicates that, in appropriately assessed obstetric patients without additional risk factors, a platelet count of at least **70,000/uL** is generally associated with a low risk of spinal epidural hematoma; this is not an unconditional threshold and should not replace individualized clinical judgment. **[26, 27]**

Management of the effects of pregnancy during spinal anaesthesia for Caesarean section:

The following principles summarize how pregnancy-related changes can be addressed during spinal anesthesia for cesarean delivery. They are general educational recommendations and must be adapted to local protocols, available resources, and the individual patient **[14, 24].**

1. **Preoperative assessment:** Evaluate maternal cardiovascular and respiratory status, airway, body habitus, obstetric urgency, medications, and relevant coagulation abnormalities.

2. **Preparation:** Ensure intravenous access, standard monitoring, a functioning vasopressor supply, appropriate airway equipment, and immediate access to resuscitation drugs.

3. **Positioning:** Optimize lumbar flexion for needle insertion and maintain left uterine displacement or an appropriate alternative after the patient is positioned supine.

4. **Drug selection:** Choose the intrathecal local anesthetic and any adjuncts according to the planned operation, clinical context, and established obstetric dosing protocols.

5. **Prevention of hypotension:** Use a prophylactic vasopressor strategy and intravenous crystalloid co-loading when appropriate.

6. **Assessment of block:** Reassess sensory level, motor block, blood pressure, heart rate, breathing, and consciousness frequently.

7. **Treatment of complications:** Correct hypotension promptly, assess bradycardia and high-block symptoms, and provide airway and circulatory support when required.

8. **Postoperative care:** Continue appropriate monitoring for residual motor block, neurological symptoms, opioid-related adverse effects, and delayed complications.

These measures are consistent with the recent recommendations for obstetric anesthesia and prevention of spinal-induced hypotension **[6,7,21,23,24,26].**

Conclusion

Pregnancy has important anatomical, physiological, and pharmacological effects on spinal anesthesia. Epidural venous engorgement, reduction in lumbosacral CSF volume, alterations in spinal curvature, and increased sensitivity to local anesthetics contribute to changes in the spread and intensity of intrathecal drugs. Cardiovascular adaptations and aortocaval compression increase the importance of preventing spinal-induced hypotension, while respiratory changes reduce maternal oxygen reserve during severe complications.

Safe spinal anesthesia for cesarean delivery requires individualized drug selection, appropriate positioning, prophylactic vasopressor therapy, fluid co-loading when indicated, careful assessment of block height, and continuous attention to maternal and fetal well-being. Understanding pregnancy-related changes enables anesthesiologists to anticipate complications and improve the quality and safety of obstetric anesthesia.

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Conflicts of interest

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