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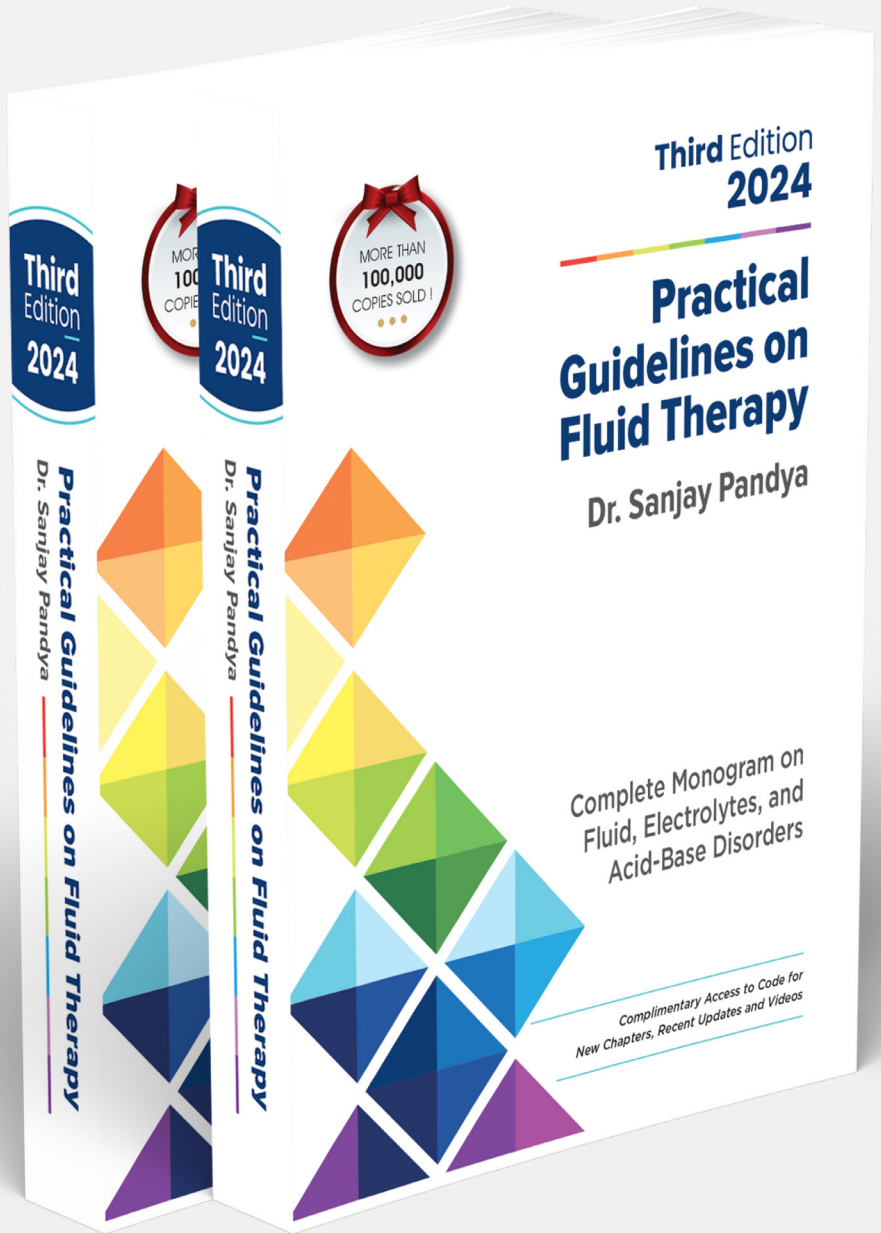
Chapter 52:

Fluid Management for Cesarean Delivery



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52 Fluid Management for Cesarean Delivery

Spinal anesthesia is the most common type of anesthesia used in cesarean sections [1].

Maternal hypotension is the most common complication of spinal anesthesia for cesarean delivery. Maternal hypotension is defined as systolic blood pressure (SBP) <90 mmHg or a reduction in mean arterial blood pressure >30% fall from baseline [2].

The incidence of maternal hypotension during spinal anesthesia for elective cesarean delivery is much higher (70–80%) [3] as compared to the incidence of hypotension caused by spinal anesthesia in nonpregnant women (about 33%) [4].

Mechanism of maternal hypotension: Spinal anesthesia blocks the sympathetic nerve fibers innervating smooth muscles of arteries and veins, which causes reduced peripheral vascular resistance and vasodilatation. Vasodilatation in the lower part of the body is the crucial mechanism of the development of hypotension due to spinal anesthesia in uncomplicated pregnancy [5].

Consequences of maternal hypotension: Maternal hypotension after spinal anesthesia for cesarean section causes both maternal and fetal/neonatal adverse effects [6]. Spinal hypotension can result in maternal nausea, vomiting, and dizziness due to a reduction in cerebral perfusion, which induces transient brainstem ischemia [7]. In addition, treatment of spinal hypotension can cause iatrogenic pulmonary edema or severe maternal hypertension. Severe and sustained hypotension can decrease uteroplacental perfusion, which can cause fetal hypoxia, acidosis, and neonatal depression [8].

MANAGEMENT OF HYPOTENSION DURING CESAREAN DELIVERY

The goal of management is to optimize maternal, uterine, and fetal perfusion,

which is crucial for the mother's safety and the baby's wellbeing.

Major steps in treating spinal hypotension are fluid loading, vasopressor, and non-pharmacological measures. Combinations of interventions will be more effective than single ones [9].

The goal of blood pressure

Treatment aims to maintain systolic blood pressure ≥100 mmHg or ≥90% of an accurately measured baseline blood pressure [10, 11].

A. Fluid loading

Before the initiation of spinal anesthesia, it is important for the patient to have large-diameter intravenous access (preferably 16 or 18 gauge) in place. This will allow for the rapid administration of fluids, medications, and blood products if necessary.

The two most important determinants for the optimal and effective treatment of spinal hypotension are: (1) The type of fluid (crystalloid compared with colloid solutions) and, (2) The timing of administration [given before spinal anesthesia (preloading) or given immediately after spinal block placement (co-loading) as rapid infusions.

1. Preloading

Preloading is a method where IV fluid is administered immediately before spinal anesthesia to reduce post-spinal hypotension (PSH).

Crystalloid preloading: Rapid administration of 10–20 mL/kg of intravenous Ringer's lactate just 15–20 minutes before spinal anesthesia was previously a routine practice to minimize hypotension resulting from sympathetic blockade. But fluid preloading with crystalloid is clinically ineffective due to its rapid redistribution and therefore is currently not recommended before spinal anesthesia [9, 12, 13].

Colloid preloading: In contrast to crystalloid preloading, colloid preloading significantly reduces hypotension and improves maternal hemodynamics [9, 14].

As preloading is not superior to co-loading (irrespective of the type of IV solution used), one should not waste significant time in administering a predetermined IV fluid volume and consequently delay spinal anesthesia initiation [15].

2. Co-loading

In co-loading, IV fluids are rapidly administered and started simultaneously with spinal anesthesia to reduce post-spinal hypotension. Using co-loading protocols is less time consuming with better (or at least similar) effects than preloading [16].

Co-loading is a more rational and physiological approach. In fluid co-loading, IV fluid administration coincides precisely with the time of the maximal vasodilatory effect of spinal anesthesia and thereby compensates for the "relative hypovolemia" and prevents post-spinal hypotension [17].

Crystalloid co-loading: A balanced electrolyte solution (e.g., Ringer's lactate solution) is the most commonly used intravenous fluid for bolus administration. Usually, a bolus of about 10–15 ml per kg or 500 to 1000 mL of Ringer's lactate is infused as fast as possible in fluid co-loading.

Use dextrose free IV fluids for crystalloid co-loading because it avoids maternal hyperglycemia. The immediate effect of maternal hyperglycemia is fetal hyperglycemia, but it may cause neonatal hypoglycemia after delivery. When dextrose containing IV fluid is administered to the mother before delivery, glucose crosses the placental barrier and can result in fetal hyperglycemia and and

hyperinsulinemia. After delivery, the glucose supply is ceased, but neonatal insulin levels are still elevated, which causes neonatal hypoglycemia [18].

The volume of fluid given during spinal anesthesia may vary depending on the patient's underlying co-morbidities and their current volume status, with a smaller volume typically being given to patients with severe preeclampsia.

Crystalloid co-loading is more effective than crystalloid preloading in preventing hypotension during spinal anesthesia for elective cesarean delivery [19–22]. Additionally, crystalloid co-loading is similar in effectiveness to colloid preloading [23].

Colloid co-loading: For colloid co-loading third generation colloids such as tetrastarch (Hydroxyethyl starch 130/0.4) seem safer than other colloids [24]. Colloid co-loading is not superior to colloid preloading [17].

Both crystalloid and colloid co-loading are equally effective in decreasing the incidence of spinal hypotension in cesarean delivery [21, 25]. However, the volume needed for colloid co-loading is less than that required for crystalloid co-loading [23].

Because of less adverse effects, lesser cost, ready availability, and restricted or second line usage of colloids in most studies [26], current literature recommends the use of crystalloids than colloids co-loading in cesarean delivery [27].

Factors affecting fluid requirements: Total requirement of intravenous fluids (crystalloids) during and after cesarean delivery varies considerably but is usually 2 to 3 liters. The requirement of fluid volume may be higher in patients with sepsis syndrome, vomiting, prolonged labor without adequate fluid intake, and increased blood loss.

In patients with preeclampsia, spinal anesthesia tends to cause less hypotension than it does in normal pregnant women. Therefore, it is recommended to use mild to moderate intravascular volume loading during spinal anesthesia in patients with preeclampsia.

The loading of a large volume of fluid carries the risk of pulmonary edema in preeclampsia [19].

B. Vasopressors

Vasopressor therapy is a crucial component in minimizing spinal hypotension. Fluid loading protocols alone are not usually sufficient to achieve reasonable control in post-spinal hypotension [16]. Besides crystalloid or colloid co-loading, a significant proportion of patients require vasopressors to control spinal hypotension [28].

Vasopressor treatment aims to restore systemic vascular resistance. Alpha-adrenergic agonist drugs are the most appropriate agents to treat or prevent hypotension following spinal anesthesia [11]. In addition, prophylactic vasopressors are superior in preventing adverse neonatal outcomes compared to reactive treatment [29].

Phenylephrine and ephedrine are the two most widely used and recommended vasoconstrictor agents in treating spinal hypotension [15]. Phenylephrine is a synthetic selective direct alpha-adrenergic agonist. Ephedrine is a synthetic mixed adrenergic agonist. Ephedrine is a stimulant that directly activates alpha and beta-adrenergic receptors and indirectly stimulates the release of endogenously stored norepinephrine. Recently, even norepinephrine (noradrenaline) has been found to be helpful in preventing and treating spinal hypotension during cesarean delivery.

1. Phenylephrine

A combined approach using titrated phenylephrine with crystalloid co-loading is

probably the best option for the management of hypotension during spinal anesthesia for cesarean section [6, 21]. Phenylephrine infusions co-administered with crystalloid has shown to eliminate the likelihood of spinal hypotension [30].

Pharmacology: Phenylephrine is a drug that acts selectively on the alpha-1 adrenergic receptors found on the vascular smooth muscle cells in blood vessels, resulting in vasoconstriction. It is a potent agent that increases total peripheral vascular resistance and increases both systolic and diastolic blood pressure. The onset of action is <1 minute, and its duration of effect is short lasting (15 to 20 minutes). At higher doses, phenylephrine can cause bradycardia due to the activation of baroreceptors, which can lead to a reduction in maternal cardiac output [31].

Preparation: Injection phenylephrine, available as a 1 ml ampoule, contains 10 mg of phenylephrine.

Method of administration (bolus vs. infusion)

In the treatment of spinal hypotension, prophylactic phenylephrine infusion is superior to bolus administration because of the lower incidence of intraoperative nausea and vomiting [32, 33]. An international consensus statement for the management of spinal hypotension by AAGBI (2018) recommends prophylactic phenylephrine infusion as the first line of management [11].

Dose: To prepare an infusion, add 1 ml (10 mg) of phenylephrine solution in 100 ml of normal saline. Each ml of this infusion will provide 100 mcg of phenylephrine (100 mcg/ml solution).

a. **IV bolus:** A commonly used dose of a prophylactic bolus of IV phenylephrine is 50 to 100 mcg (0.5 to 1 ml). Repeat the dose every 2 to 5 minutes as required, but do not give more than a total dose of 200 micrograms (mcg).

b. **IV infusion:** Currently recommended dose of phenylephrine infusion is 25–50 mcg/min. (0.25 to 0.5 ml/min) [11, 16] Prophylactic phenylephrine infusion is started with an infusion pump as soon as the spinal anesthesia is given. The dose is titrated according to maternal systolic blood pressure response and pulse rate.

   A higher incidence of post-spinal hypotension occurs with the lower dose (25 mcg/min), and a higher incidence of reactive hypertension and bradycardia occurs with the higher dose (50 mcg/min) [31, 34].

c. **IV bolus followed by infusion:** When phenylephrine is infused after spinal anesthesia, there will be a delay in achieving adequate blood pressure levels. However, an initial phenylephrine bolus immediately after the spinal anesthesia, followed by a phenylephrine infusion, will maintain blood pressure without adverse effects [5].

2. Ephedrine

Ephedrine is a sympathomimetic drug that stimulates both alpha and beta-adrenergic receptors. As a result, it stimulates the heart rate, increases cardiac output, and variably increases peripheral resistance, leading to an increase in blood pressure.

Previously, ephedrine was the first-line treatment for spinal hypotension. But the trend to use ephedrine in the treatment of post-spinal anesthesia hypotension is decreasing because:

- Repeated administration of ephedrine diminishes its vasoconstrictive effect [35].
- Delayed onset of action of ephedrine may result in a longer period of hypotension than phenylephrine.

- The relatively long duration of the effect of ephedrine makes accurate titration of blood pressure difficult [36].
- Ephedrine may increase the risk of fetal acidosis by crossing the placenta to a greater extent [37].

Currently, ephedrine is preferred to treat spinal hypotension in a pregnant patient with bradycardia, as it typically increases heart rate.

The commonly used dose of ephedrine is 5 to 10 mg IV boluses or 1 to 5 mg/min IV infusion.

3. Phenylephrine versus ephedrine

Ephedrine was previously the first-line therapy for parturients with spinal hypotension [38]. But phenylephrine is currently vasopressor of choice in the treatment of spinal hypotension in the absence of maternal bradycardia [39–41]. Reflex bradycardia and decreased cardiac output are the primary concerns associated with phenylephrine.

As compared to ephedrine, phenylephrine is preferred and superior because of its faster onset [42], ease to titrate, better preservation of uterine blood flow, does not cause or worsen maternal tachycardia [43, 44], less reactive hypertension [45], less incidence of fetal acidosis [46], and less maternal nausea and vomiting [47, 48].

However, ephedrine may be more beneficial in patients with bradycardia, compromised cardiac functions, uteroplacental insufficiency, and pre-eclampsia [16].

Vasopressor selection based on maternal heart rate:

- Hypotension and tachycardia: This is the usual response to spinal anesthesia, and phenylephrine is a preferred vasoconstrictor agent in treatment.
- Hypotension and bradycardia: This is the unusual response that resembles a vagal reaction; rather than 'appropriate' tachycardia and vasoconstriction. Ephedrine is a preferred vasoconstrictor agent for spinal hypotension associated with bradycardia [40].

4. Norepinephrine as vasopressor

Norepinephrine (NE, noradrenalin) is recently introduced to prevent and treat spinal hypotension during cesarean delivery [49, 50]. Norepinephrine (NE) is a potent vasopressor having both alpha-adrenergic agonistic activity, and weak beta-adrenergic agonistic activity. NE has minimal cardiac depressant effect [51]. NE has a similar effect to phenylephrine in maintaining blood pressure but may be associated with higher heart rates (closer to baseline), and greater cardiac output [52, 53].

Because of beneficial cardiac effects and potency, NE may be preferred in mothers with low baseline heart rates or poor cardiac function, where phenylephrine is relatively contraindicated [51].

More research is needed to evaluate the safety and efficacy of norepinephrine before its routine use in obstetric patients [51, 54]. Table 52.1 summarizes all vasopressors used in spinal hypotension during cesarean delivery.

C. Non-pharmacological measures

In the supine position, the gravid uterus compresses the maternal abdominal aorta and inferior vena cava, which decreases cardiac output [55]. Positioning protocols for the prevention of post-spinal hypotension are targeted to relieve aortocaval compression imparted by the gravid uterus and increase venous return [16]. Left lateral uterine displacement with 15° table tilt reduces inferior vena cava compression and is

routinely recommended in addition to other measures [11, 56, 57].

POSTOPERATIVE CARE AFTER CESAREAN DELIVERY

Early oral intake

After cesarean delivery, fluids or food is traditionally avoided until bowel functions return (confirmed by bowel sounds or passage of flatus or stools). But in uncomplicated cesarean delivery, evidences to justify the restriction of oral fluids or food is lacking.

Current evidence suggests that early oral intake (within six hours of delivery) may have several benefits for postpartum care. These benefits include promoting the return of bowel function (through the stimulation of the gastrocolic reflex), encouraging early ambulation, reducing the duration of intravenous fluid administration, decreasing the risk of sepsis, shortening the time to breastfeeding, decreasing the length of hospital stay, and reducing the cost of hospitalization [58–61].

Nausea and vomiting after cesarean delivery can delay early oral intake. In the management of postoperative nausea

Table 52.1 Vasopressors in spinal hypotension during cesarean delivery

Vasopressor	Phenylephrine	Ephedrine	Norepinephrine (noradrenaline)
Mechanism of action	Selective direct α 1 receptor agonist	Direct α and β agonist and indirect release of norepinephrine	Direct α 1 and β 1 agonist
Arterial vasoconstriction	Potent	Less potent	Potent
Chronotropic effect	Negative	Positive	Positive
Maternal heart rate	Reflex bradycardia	Tachycardia	Increased
Cardiac output	Decrease	Increase	Modest increase
Onset of action	Faster	Slower	Immediate
Duration of action	Short-acting (15 to 20 minutes)	Relatively long duration (about 60 min), so longer period of hypotension	Very short (1 to 2 minutes)
Advantage	No maternal tachycardia, better titratability	No maternal bradycardia	Less negative effects on heart rate and cardiac output
Selection	Currently preferred vasopressor in post-spinal hypotension. Preferred in maternal tachycardia	Preferred in maternal bradycardia in post-spinal hypotension	Beneficial effects in mothers with bradycardia and compromised cardiac function in recent studies
Strength of injectable solution and dilution	10 mg/mL (1 mL diluted in 100 ml of normal saline equals 100 mcg/mL)	30 mg/mL, 50 mg/mL (1 mL diluted in 10 ml of normal saline equals 3 mg/mL or 5 mg/mL)	1mg/mL (2 mL diluted in 500 ml of D5W or D5NS equals 4 mcg/mL)
Commonly used doses	50 to 100 mcg IV bolus or 25 to 100 mcg/min IV infusion	5 to 10 mg IV boluses or 1 to 5 mg/min IV infusion	Further studies are required before its routine use

and vomiting (PONV), the combination of anti-emetics is more effective than monotherapy [62].

During cesarean delivery, intraoperative nausea and vomiting (IONV) are common [7]. Measures to reduce IONV during cesarean are the prevention of hypotension with liberal perioperative administration of IV fluids, maintaining normal blood pressure with prophylactic use of vasopressors (i.e., phenylephrine or ephedrine), administration of anti-emetics (metoclopramide and ondansetron) and minimizing visceral manipulation (e.g., uterine exteriorization) [63, 64].

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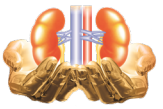
KidneyEducation 

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