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**Original Research Paper**

# Effectiveness of RL preload hydration in preventing hypotension in post-spinal anesthesia patients

**Irwadi Irwadi[1*], Andre Utama Saputra[2]**
Department of Nursing Anesthesiology, Faculty of Vocational Studies, Universitas Baiturrahmah, Padang City,Indonesia
Department of Nurse Profession, Faculty of Midwifery and Nursing,Universitas Kader Bangsa, Palembang City, Indonesia
irwadi@staff.unbrah.ac.id

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## Abstract
Hypotension often occurs in spinal anesthesia patients due to suppression of the autonomic nervous system, specifically the sympathetic nerve, leading to vasodilation. This study aims to evaluate the effectiveness of preloading RL in preventing hypotension. The design uses a quasi-experiment with a pretest-posttest design with a control group. A total of 50 respondents were selected by purposive sampling and divided into intervention and control groups. Blood pressure data was measured using a NIBP monitor and recorded on an observation sheet. The results showed that the average systolic and diastolic pressure in the intervention group was 125.20 mmHg and 81.24 mmHg, in the control group was 115.20 mmHg and 70.57 mmHg. The paired sample t-test showed a significant difference ($p < 0.05$). Preload RL is effective in preventing hypotension in spinal anesthesia.

**Keywords**: hypotension; lactate ringer; spinal anesthesia

## 1. Introduction

Spinal anesthesia is a regional anesthesia technique that can be used in various types of surgeries, especially in lower surgery such as orthopedics, obstetrics, and urology (Forkin et al., 2016). Regional anesthesia works by suppressing or inhibiting the transmission of nerve impulses in a specific area of the body, thus causing the loss of pain in that part without affecting the patient's consciousness (Morgan & Mikhail's, 2022). This mechanism occurs through nerve conduction blockade, mainly by inhibiting sodium channels in nerve cell membranes by suppressing sensory, motor, and autonomic nerve impulses in body parts. Anesthesia is administered in the subarachnoid space, thus blocking the transmission of nerve impulses in the lower segment of the spinal cord. (Niazi & Matava, 2019).

Spinal anesthesia is growing and widely used, and the advantages offered include a relatively lower price, small systemic influence, adequate analgesia and the ability to prevent a more complete stress response (Neuman et al., 2023). Anesthesia in addition to having advantages can also cause a decrease in sensory and motor functions in the body below the injection point and also suppress the autonomic nervous system, especially sympathetic nerve fibers, which causes vasodilation and a decrease in blood pressure (hypotension) (Wink , 2019) . The incidence of hypotension in spinal anesthesia is caused by several factors, namely the type of local anesthetic drug, the degree of sensory inhibition, age, gender, weight, physical condition of the patient, the patient's position, and surgical manipulation. The most common side effect of spinal anesthesia is hypotension as a result of sympathetic blocks in the subarachnoid space. (Ferre et al., 2020).

Based on a 2020 report by the Centers for Disease Control and Prevention (CDC), it is stated that spinal anesthesia often causes hypotension as a frequent complication, with incidence ranging from

30% to 40% in adults undergoing other lower body surgery procedures (CDC, 2020) . The prevalence of hypotension in the United States found that the incidence of mild, moderate, and severe hypotension after spinal anesthesia was 31.4%, 23.9%, and 30.1%, respectively, making it a common complication during surgery (DASM, 2023) . While data in Indonesia shows that hypotension in spinal anesthesia is still a common problem, a percentage of incidence is obtained of 30 to 33% of patients experiencing hypotension (Karnina et al., 2022) . Hypotension after spinal anesthesia is a common occurrence, with a prevalence varying between 30% to 70%, depending on the type of procedure and the patient's condition. In procedures such as caesarean sections, the prevalence can reach about 39% to 75% (Guarracino & Bertini, 2022).

Hypotension is a decrease in arterial blood pressure >20% below baseline or absolute values of systolic blood pressure below 90 mmHg and diasole below 60 mmH (Ministry of Health , 2023) . Hypotension during spinal anesthesia occurs more often than in other types of anesthesia. The incidence of decreased blood pressure in patients receiving spinal anesthesia can increase by more than 20%, especially due to the sympathetic blockade effect that leads to a decrease in peripheral vascular resistance as well as this condition is potentially more commonly experienced by patients with risk factors such as advanced age or comorbidities (Ferre et al., 2020). This is caused by several factors related to partiurian conditions, including high intra-abdominal pressure, increased vasodilation due to spinal anesthesia, decreased systemic vascular resistance, and increased oxygen demand (Chen et al., 2023). Because of these factors, parturiens are more susceptible to hypotension during spinal anesthesia. Active management, such as adequate intravenous hydration, vasopressor administration, and left lateral positioning to reduce compression of the vena cava, is often necessary to maintain hemodynamic stability and prevent complications in the patient (Valverde , 2021).

Hypotension, if it lasts for a long time and is not treated immediately, can cause a number of serious complications such as decreased perfusion of vital organs, decreased cardiac output, hypoperfusion of the uteroplacenta in the parturien, lactic acidosis, systemic tissue damage and hypotensive shock (Chen et al., 2021). The quick and appropriate management of hypotension patients is essential in order to prevent these serious complications by providing interventions such as intravenous fluid preloading, vasopressor medications, and patient position management are often necessary to restore blood pressure and maintain vital organ perfusion to maintain hodynamics (Castera & Borhade, 2023). Preloading fluids with crystaloids, such as Ringer Lactate (RL), is often used as a preventive measure to overcome hypotension induced by spinal anesthesia (Tiruneh et al., 2021). Since RL has a similar composition to extracellular fluids, it is the main choice for overcoming and preventing hypotension during anesthesia where the balanced electrolyte composition of RL contains sodium (130 meq/l), potassium (4 meq/l), calcium (3 meq/l), and chloride (109 meq/l), which is close to the concentration of electrolytes in the body's extracellular fluids (James & Dyer, 2018). Making RL effective in replacing extracellular fluid loss without disrupting the body's electrolyte balance (Eli et al., 2024). Because RL is similar to extracellular fluid, its use provides a more physiological fluid and blood pressure stabilizing effect, making it an excellent resuscitation fluid during surgical procedures and anesthesia (Mane, 2017).

The advantages of RL include low prices, easily available in every health center, no need to do cross matching, no allergies or anaphylactic shock, simple storage and can be stored for a long time (Valverde, 2021). The half-life of RL in the intravascular space is about 20-30 minutes. This means that once administered, most of the volume of RL will exit the intravascular space and enter the interstitial space within that time (Jacob et al., 2012). In general, preload is carried out 15-30 minutes before the spinal anesthesia procedure is carried out with the number of lactate ringers given 10-15cc/kgbb(Horejsek et al., 2022). Where the purpose of this preload is to increase intravascular volume and reduce the risk of hypotension that may occur due to the effects of spinal anesthesia (Castera & Borhade, 2023).

A meta-analysis conducted by (Najm et al., 2023) showed that preloading of fluids significantly reduced the frequency and degree of hypotension in patients undergoing spinal anesthesia. Analyses were conducted by Khosravi et al., (2019) that showed the effectiveness of hydration preload with RL in preventing hypotension from various studies comparing groups that received fluid preload with those that did not show that fluid preloading may help reduce the incidence of post-anesthesia hypotension, especially in patients undergoing spinal anesthesia procedures. The results showed an increase in hemodynamic stability in the group that was given fluid preload compared to the control group. These findings support clinical practice in the use of crystalloid fluids as a preventive measure against hemodynamic complications resulting from spinal anesthesia. The study by (O'Rourke et al., 2019) showed that the administration of preload fluid was very effective in preventing hypotension during the spinal anesthesia procedure of the 30 participants tested, 24 did not experience hypotension after the administration of preload fluid, which showed an effectiveness rate of 86.7%.

The administration of RL fluid preload of 10-15 cc/kg of body weight is carried out approximately 15-20 minutes before the spinal anesthesia action to increase intravascular volume and fight hypotension due to sympathetic blockade with RL administration and should be balanced with strict hemodynamic monitoring to avoid the risk of complications such as edema or electrolyte imbalance (Rijs et al., 2020). Study conducted by Decuyper and Van De Velde, (2023) comparing cloding and preloding explain that preloading with crystalloid fluid done before spinal anesthesia effectively prevents complications of hypotension, because preloading with RL fluid helps offset this loss of blood volume by increasing intravascular fluid, thus preventing a drop in blood pressure.

The type of fluid given also plays an important role in the stability of the hemodynamic response ( Castera & Borhade, 2023). Crystaloids, such as lactate ringers, are often used for their ability to quickly fill intravascular spaces, although only 25% of the given volume remains in circulation after a few hours (Kemp, 2020). Giving enough fluids in the amount of 500-1000 cc can increase blood pressure (Wu et al., 2020). Although the critaloid fluid quickly distributes ecstasy, it also has the potential to cause a decrease in heart rate due to an excessive increase in preload, which can decrease the body's sympathetic response (Valverde, 2021). Conversely, excessive amounts of fluids can lead to hypertension, pulmonary edema, and other complications such as heart disorders (Stickel et al., 2019). Therefore, it is important to provide appropriate fluid therapy to ensure optimal postoperative recovery (O’Rourke et al., 2019). Therefore, the supervision of officers in administering fluids needs to be adjusted to the patient's individual condition, including pre-operative status, intraoperative blood loss, and fluid needs during recovery. (Castera & Borhade, 2023).

A preliminary study at Pariaman Hospital in July-August 2023 showed that out of 330 spinal anesthesia procedures, many patients did not receive RL fluid preload due to the busy surgery schedule. Of the 15 patients who were given spinal anesthesia, 9 patients experienced hypotension. This study aims to test the effectiveness of RL preload hydration in preventing hypotension in patients after spinal anesthesia at the Central Surgical Installation of Pariaman Hospital.

## 2. Research Methods

This type of research is quantitative research. Quasy Experiment design, pretest-posttest with control group. This research was carried out from February 1 to 28, 2024. The population in this study is patients with spinal anesthesia at the Central Surgical Installation of Pariaman Hospital totaling 330 in July-August 2023. The sample in this study was taken using purposive sampling, this method was chosen because the study required participants with specific characteristics that were relevant to the purpose of the study. The number of samples in this study was 50 consisting of 25 controls and interventions and those that met the inclusion criteria were selected. Inclusion criteria are surgical patients with spinal anesthesia techniques, patients aged 17-55 years, physical status of the American

Society of Anesthesiologist (ASA) I and II, Patients with lower abdominal surgery, pelvis, peri-rectum-perineal surgery, herniotomy, appendectomy, hemorrhoidectomy, ureteroscopy and gynecological obgyn surgery, while the exclusion criteria are acidic with medical conditions of severe heart disorders or acute infections and patients who have no contraindications to the administration of fluids. The instrument used to measure in this study with non-invasive blood pressure (NIBP) uses an automatic blood pressure cuff on the side monitor. Data were collected using questionnaire sheets for collecting demographic data and observation sheets to collect data on sistole and diastole examinations. In the intervention group, RL preload fluid was given at a dose of 10-15 cc/kg of body weight. Measurements are taken after preload RL and before the spinal anesthesia procedure with the patient in a supine position 10-15 minutes to get the initial value of the patient's blood pressure and after the postoperative spinal anesthesia, the blood pressure is measured at 30 after the patient is in the recovery room. 30 minutes is enough to see if the patient has begun to recover from the effects of the anesthesia so that the effect of fluid preload on blood pressure can be maintained for a long period of time. During the questionnaire, the respondent may ask questions that are not understood and make a time contract with the patient at the beginning by signing informed consent to become a research respondent, meaning that the patient expresses a willingness to participate in the study voluntarily and without pressure. Data analysis using parametric statistics, paired tests, t-tests were used to compare the mean blood pressure before and after the intervention in one group, both the intervention and control groups. This test tested whether there was a significant difference in mean blood pressure before and after treatment in the group.

## 3. Results and Discussion

### 3.1.Characteristics of Respondents

**Table 1.** Frequency Distribution of Respondent Characteristics Based On Gender, Age, ASA

| Characteristic | Preload RL (=25) | | Tampa Preload RL (=25) | |
|---|---|---|---|---|
| | f | % | f | % |
| **Gender** | | | | |
| Men | 15 | 60 | 14 | 56 |
| Woman | 10 | 40 | 12 | 44 |
| **Age** | | | | |
| Early Adult 26-35 Years | 9 | 36 | 12 | 48 |
| Late Adult 36-45 years old | 12 | 48 | 9 | 36 |
| Early Elderly Adults 46-55 years old | 4 | 16 | 4 | 16 |
| **Hope** | | | | |
| ASA I | 11 | 44 | 12 | 48 |
| ASA II | 14 | 56 | 13 | 52 |

Source: Primary Data, 2024

Based on Table 1, the proportion of male patients is higher than that of women. In the intervention group, as many as 60% of males and in the control group 56%, this difference shows the dominance of male patients in both groups. According to Dart et al., (2022) the explanation, the difference in response to fluids between men and women is caused by various physiological factors. For example, gender suggests that men and women have differences in hormone regulation that can affect blood pressure regulation and response to fluid therapy. Estrogen, the more dominant hormone in women, may play a role in regulating blood pressure, so the response to fluid administration may differ between the two sexes. As well as differences in body size and body composition also contribute to women generally having a smaller body weight and blood volume than men, which means the dose of fluid given must be adjusted, this is important to avoid side effects such as fluid overload or hypertension.(Dart et al., 2022).

Age category in the Intervention group, the majority of patients were in the late adult group of 36-45 years as much as 48%, in the control group, the oldest age distribution in early adults 26-35 years was 48% The two groups had different age distributions. The patient's age can affect the hemodynamic response to fluid preload, such as RL where as we age, there is a possibility of decreased heart function and increased vascular resistance, which can affect how the body responds to the volume of additional fluid. Elderly patients may have less preload reserve, i.e. the ability to increase cardiac output by increasing fluid volume, potentially reducing the positive response to RL preload (Martin et al., 2020).

In the American Society of Anesthesiologists (ASA) status in the intervention group, the proportion of patients with ASA II status (56%) was more while in the control group, the proportion of ASA I was more (48%) which showed that the physical condition of the patients was relatively balanced in both groups. According to Perel, (2020), the patient's response to preload is also influenced by the status of ASA. Healthier patients (ASA I or II) generally show a better response to preload, with more significant increases in blood pressure and cardiac output. Conversely, if the ASA status is higher, it is likely not responding optimally due to limitations in their heart or lung function. Patients with higher ASA status are more susceptible to side effects of fluid overload (Maheshwari & Sessler, 2020).

### 3.2. Effectiveness of RL Preload Hydration in Preventing Hypotension in Patients After Elective Surgical Spinal Anesthesia

**Table 2.** Effectiveness of RL preload hydration on blood pressure in elective postoperative patients

| Variable | Group | n | Result | Mean | SD | Min - Max | P Value |
|---|---|---|---|---|---|---|---|
| Sistole | Preload RL | 25 | Before | 125.38 | 3.841 | 118-132 | 0.000 |
| | | 25 | After | 125.20 | 5.979 | 110-138 | |
| | Tampa | 25 | Before | 125.44 | 6.187 | 110-132 | 0.000 |
| | Preload RL | 25 | After | 115.20 | 9.840 | 100-125 | |
| Diastole | Preload RL | 25 | Before | 80.00 | 4.628 | 79-90 | 0.000 |
| | | 25 | After | 81.24 | 6.424 | 70-97 | |
| | Tampa | 25 | Before | 79.44 | 8.186 | 68-97 | 0.002 |
| | Preload RL | 25 | After | 70.52 | 9.474 | 58-96 | |

Source: Primary Data, 2024

Table 2 shows that the results of the intervention in the preloading of RL fluid, the average range of systole blood pressure before 125.38 mmHg and after systole blood pressure is 125.20, while the average value of diastatic blood pressure measurement before the intervention is 80.00 mmHg and after surgery is 81.24 mmHg in the intervention group. Meanwhile, in the control group, the average blood pressure of systole before 125.44 mmHg and blood pressure of systole after surgery was 115.20, while in the measurement value of diastole blood pressure before the average value was 79.44 mmHg and after diastole blood pressure was 70.52 mmHg. After the data was tested using the Paired test, the t-test sample obtained the P value of blood pressure systole and diastole in both groups <0.005.

This study is in line with Najm et al., (2023) the discussion about RL fluid proload to prevent hypotension with the results in the intervention group the average sistole pressure before which was 126.10 mmHg, and after the surgery there was a slight decrease to 125.60 mmHg, while in the diastole blood pressure the average before 82.00 mmHg, and after the surgery there was a slight increase to 82.70 mmHg. And in the control group, the blood pressure of the systole before surgery was 123.80 mmHg, after the operation it decreased to 123.90. The diastole blood pressure before was 80.50 mmHg, and after the operation showed a decrease of 78.60 mmHg, the results of the statistical test in both groups obtained a p value of <0.005. The results of this study are also supported by (Borse et al., 2020) research that discusses the effect of RL fluid preload on blood pressure measurement during surgery. Comparing systolic and diastolic pressures across the intervention and control groups, showed there was a statistically significant difference (p-value <0.005). These results are aligned with clinical practice of fluid management during anesthesia to maintain hemodynamic stability.

The results of this study are not in line with the research conducted by Sathyavrdhan & Kamath, (2024), which found that the administration of RL preload hydration did not have a significant effect on the reduction of hypotensive incidence in patients with an operative duration of more than 2 hours, even though the preload fluid was administered according to the recommended protocol. In surgery with a longer duration, the effect of fluid preload may not be enough to maintain blood pressure over a long period of time, given the effects of anesthesia which include blood loss, changes in intravascular volume, and the body's response to anesthesia.  (Malbrai, 2020).

Studies conducted by Quarshie et al., (2023) showed that preloading RL was not effective in preventing a decrease in the incidence of hypotension in patients with hypertension, even though preloading fluids were administered. This indicates that individual factors, such as the patient's medical condition, can affect the outcome and require further consideration in the application of fluid preload in specific groups. In addition, research also shows that RL preloading is not always effective in preventing post-anesthesia hypotension, one of which is due to the long duration of surgery (Malbrai, 2020). A patient's health condition, such as age, comorbidities (e.g. hypertension, diabetes, or heart disease), and the status of body fluid volume, can also affect the effectiveness of preloading in preventing hypotension. (Najm et al., 2023)

The incidence of hypotension in patients undergoing spinal anesthesia surgery physiologically often experiences a decrease in blood pressure, which can cause this hypotension because spinal anesthesia drugs dilate blood vessels, decreasing systemic vascular resistance (Ferre et al., 2020a). To address these issues, fluid administration before spinal anesthesia injection can help reduce the vasodilating effects of anesthetic drugs by increasing blood volume. One of the fluids given is RL (Castera & Borhade, 2023). RL fluid is a type of isotonic crystalline liquid that contains important electrolytes such as sodium, potassium, calcium, chloride, and lactate and this solution has the same composition as the fluid in the body so that it is able to maintain electrolyte balance and blood volume (Miller & Myles, 2019).

Preloading with RL in addition to preventing hypotension because it can increase intravascular volume, preloading helps maintain blood pressure during anesthesia, and prevents the occurrence of vasodilation and decreased blood vessel tone caused by spinal block (O'Rourke et al., 2019) . Crystalline fluids such as RL are often used because of their similarity to the composition of body fluids. Doses of 500-1000 cc are usually effective in increasing blood pressure, but they should be adapted to the patient's clinical condition, such as a history of heart disease or other comorbid conditions (Wu et al., 2020). And it is important to monitor the patient's response to fluid administration, since excessive fluid administration can lead to complications, such as volume overload and pulmonary edema (Stickel et al., 2019).

The results of this study provide important insights into the benefits of preload hydration prior to spinal anesthesia induction to maintain hemodynamic stability in elective surgery patients. These findings can be applied to the management of preoperative patients in hospitals, by implementing more structured preload fluid administration, thereby reducing the incidence of post-anesthesia hypotension, accelerating patient recovery, and reducing the need for further therapeutic interventions. In addition, the application of the results of this study can improve patient safety and comfort, thus, it is expected that the quality of care for patients undergoing spinal anesthesia will be improved, with a reduced risk of hemodynamic complications and better postoperative recovery.

The study highlights that, although blood pressure fluctuations are not drastic, the ability of RL preload to maintain systolic and diastolic pressure in a narrow range is crucial in ensuring patient stability during and after spinal anesthesia. Even small drops in blood pressure, especially systolic, can have a profound effect on organ perfusion and patient outcomes. By minimizing these changes, RL preload helps prevent perioperative complications associated with hypotension. However, the success of preloading Rl depends on the response of the patient related to age, gender and physical fitness. In conclusion, the data support the hypothesis that RL preload hydration is an effective intervention to prevent significant hemodynamic changes in patients undergoing spinal anesthesia, contributing to safer surgical outcomes.

## 4. Conclusion

This study shows that the administration of RL preload hydration is effective in maintaining blood pressure stability in elective postoperative patients. In the intervention group, systolic and diastolic blood pressure remained stable, while in the control group there was a significant decrease, especially in diastolic pressure. Statistical analysis showed a significant difference between the two groups ($p < 0.005$), supporting the effectiveness of RL preload in preventing significant hemodynamic changes during surgery. These findings support the application of RL preload as a standard protocol in perioperative management, contributing to improved patient safety and clinical service efficiency. The results of this study broaden the insight into the role of RL preload hydration in anesthesiology, encourage the development of more personalized protocols and open up further research opportunities to explore more optimal fluids or interventions in a variety of operative conditions.

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## References

Borse, Dr. Y. M., Patil, Dr. A. P., Subhedar, Dr. R. D., & Sangale, Dr. S. V. (2020). Comparative study of preloading and Co-loading with ringer lactate for prevention of spinal hypotension in elective cesarean section. *International Journal of Medical Anesthesiology*, *3*(1), 30–32. https://doi.org/10.33545/26643766.2020.v3.i1a.66

Castera, M. R., & Borhade, M. B. (2023). Fluid Management. In *In StatPearls*. Cape Fear Valley Hospital.

CDC. (2020). *Postural Hypotensi*. Kementrian Kesehatan RI. https://www.cdc.gov/steadi/pdf/steadi-brochure-postural-hypotension-508.pdf

Chen, X., Xu, J., Li, Y., Shen, B., Jiang, W., Luo, Z., Wang, C., Teng, J., Ding, X., & Lv, W. (2021). The Effect of Postoperative Fluid Balance on the Occurrence and Progression of Acute Kidney Injury After Cardiac Surgery. *Journal of Cardiothoracic and Vascular Anesthesia*, *35*(9), 2700–2706. https://doi.org/10.1053/j.jvca.2020.10.007

Chen, Y., Xu, X., Qin, R., Guo, L., & Ni, X. (2023). Comparison of crystalloid and colloid co-load combined with norepinephrine prophylaxis on post-spinal anesthesia hypotension during cesarean delivery: a randomized sequential allocation dose-finding study. *Frontiers in Medicine*, *10*(September), 1–7. https://doi.org/10.3389/fmed.2023.1214598

Dart, A. M., Du, X. J., & Kingwell, B. A. (2022). Gender, sex hormones and autonomic nervous control of the cardiovascular system. *Cardiovascular Research*, *53*(3), 678–687. https://doi.org/10.1016/S0008-6363(01)00508-9

DASM. (2023). Incidence and Associated Factors of Postoperative Undesirable Anesthetic Outcomes Among Surgical Patients at Referral Hospitals in Amhara Region, Ethiopia: A Multi-Center Study. *Patient Related Outcome Measures*, *Volume 14*(May), 137–152. https://doi.org/10.2147/prom.s403697

Decuyper, N., & Van De Velde, M. (2023). Fluid co-loading or preloading for the prevention of hypotension during spinal anesthesia for C-section: a narrative review. *Acta Anaesthesiologica Belgica*, *74*(2), 113–121. https://doi.org/10.56126/74.1.09

Eli, C., Aiden, G., Alex, C., Victor, M., Kumar, D., & Livi, S. (2024). Ringer ' s Lactate in Acute Care : Indications , Mechanisms , and Administration. *Reseachgate*, *August*. https://doi.org/10.13140/RG.2.2.19414.46403

Ferre, F., Martin, C., Bosch, L., Kurrek, M., Lairez, O., & Minville, V. (2020a). Control of spinal anesthesia-induced hypotension in adults. *Local and Regional Anesthesia*, *13*, 39–46. https://doi.org/10.2147/LRA.S240753

Ferre, F., Martin, C., Bosch, L., Kurrek, M., Lairez, O., & Minville, V. (2020b). Control of spinal anesthesia-induced hypotension in adults. In *Local and Regional Anesthesia* (Vol. 13, pp. 39–46). Dove Medical Press Ltd. https://doi.org/10.2147/LRA.S240753

Forkin, K. T., C., E., & Nemergut. (2016). *Anesthesiology* (8th ed., Vol. 124, Issue 4). Albany Medical. https://doi.org/https://doi.org/10.1097/ALN.0000000000001020

Guarracino, F., & Bertini, P. (2022). Perioperative hypotension: causes and remedies. In *Journal of Anesthesia, Analgesia and Critical Care* (Vol. 2, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s44158-022-00045-8

Horejsek, J., Kunstyr, J., Michalek, P., & Porizka, M. (2022). Novel Methods for Predicting Fluid Responsiveness in Critically Ill Patients—A Narrative Review. *Diagnostics*, *12*(2). https://doi.org/10.3390/diagnostics12020513

Jacob, M., Chappell, D., Hofmann-Kiefer, K., Helfen, T., Schuelke, A., Jacob, B., Burges, A., Conzen, P., & Rehm, M. (2012). The intravascular volume effect of Ringer's lactate is below 20%: A prospective study in humans. *Critical Care*, *16*(3). https://doi.org/10.1186/cc11344

James, M. F. M., & Dyer, R. A. (2018). *Clinical Fluid Therapy in the Perioperative Setting*. Cambridge University Press.

Karnina, R., Rahmadani, S., & Faruk, M. (2022). Incidence oWink, Jeroen; Bernadette T, m.d.; wouters, patrick f. 2019. "Effects of Thoracic Epidural Anesthesia Regulation and Cardiac." Thoracic Epidural Anesthesia and the Heart Medical 130(3):472–91.f Hypotension, Bradycardia, and Post-operative Nausea. *Open Access Macedonian Journal of Medical Sciences*, *10*(B), 1602–1606. https://doi.org/10.3889/oamjms.2022.9024

Kemenkes. (2023). *Hipotensi*. https://yankes.kemkes.go.id/view_artikel/2324/hipotensi

Kemp, M. E. A. (2020). Crystalloids and colloids. *Southern African Journal of Anaesthesia and Analgesia*, *26*(6), S80–S85. https://doi.org/10.36303/SAJAA.2020.26.6.S3.2544

Khosravi, F., Alishahi, M., Khanchemehr, Y., & Jarineshin, H. (2019). A Comparison Between the Effects of Preloading with Ringer's Solution and Voluven on Hemodynamic Changes in Patients Undergoing Elective Cesarean Section Under Spinal Anesthesia. *Medical Archives (Sarajevo, Bosnia and Herzegovina)*, *73*(1), 44–48. https://doi.org/10.5455/medarh.2019.73.44-48

Maheshwari, K., & Sessler, D. I. (2020). Goal-directed Therapy: Why Benefit Remains Uncertain. *Anesthesiology*, *133*(1), 5–7. https://doi.org/10.1097/ALN.0000000000003337

Malbrai, M. (2020). Intravenous fluid therapy in the perioperative and critical care setting: Executive summary of the International Fluid Academy (IFA). In *Annals of Intensive Care* (Vol. 10, Issue 1). Springer. https://doi.org/10.1186/s13613-020-00679-3

Mane, A. S. (2017). Fluid Resuscitation: Ringer Lactate Versus Normal Saline-A clinical Study. *International Journal of Contemporary Medical Research*, *4*(11), 2454–7379.

Martin, N. D., Codner, P., Greene, W., Brasel, K., & Michetti, C. (2020). Contemporary hemodynamic monitoring, fluid responsiveness, volume optimization, and endpoints of resuscitation: An AAST critical care committee clinical consensus. *Trauma Surgery and Acute Care Open*, *5*(1), 1–5. https://doi.org/10.1136/tsaco-2019-000411

Miller, T. E., & Myles, P. S. (2019). Perioperative Fluid Therapy for Major Surgery. *Anesthesiology*, *130*(5), 825–832. https://doi.org/10.1097/ALN.0000000000002603

Morgan, & Mikhail's. (2022). *Clinical Anesthesiology* (7, Ed.). Mc Graw Hill Lange.

Najm, Dr. E. S., Fadhil, Dr. A. A., & Shibli Younis, Dr. R. M. (2023). The Effect of Fluid Preloading on the Incidence of Hypotension During Spinal Anesthesia. *Journal of Prevention, Diagnosis and Management of Human Diseases*, *34*, 26–35. https://doi.org/10.55529/jpdmhd.34.26.35

Neuman, M. D., Sieber, F., & Dillane, D. (2023). Comparative Effectiveness Research on Spinal versus General Anesthesia for Surgery in Older Adults. *Anesthesiology*, *139*(2), 211–223. https://doi.org/10.1097/ALN.0000000000004604

Niazi, A., & Matava, C. (2019). *Anesthesia for Medical Students* (3rd ed.). University Of Toronto.

O'Rourke, K., Morrison, B., Sen, S., & Jones, C. (2019). Fluid management for enhanced recovery surgery. *Digestive Medicine Research*, *2*(2), 37–37. https://doi.org/10.21037/dmr.2019.09.05

Perel, A. (2020). Using Dynamic Variables to Guide Perioperative Fluid Management. *Anesthesiology*, *133*(4), 929–935. https://doi.org/10.1097/ALN.0000000000003408

Quarshie, A., Anno, A., Djagbletey, R., Sarpong, P., Sottie, D., Phillips, B. J., Lassey, P. D., Aryee, G., Essuman, R., & Owusu Darkwa, E. (2023). Comparison of Crystalloid Preloading and Coloading for Prevention of Spinal-induced Hypotension in Cesarean Delivery: A Randomized Controlled Trial at a Tertiary Facility in Ghana. *Open Access Macedonian Journal of Medical Sciences*, *11*(B), 627–633. https://doi.org/10.3889/oamjms.2023.11657

Rijs, K., Mercier, F. J., Lucas, D. N., Rossaint, R., Klimek, M., & Heesen, M. (2020). Fluid loading therapy to prevent spinal hypotension in women undergoing elective caesarean section: Network meta-analysis, trial sequential analysis and meta-regression. *European Journal of Anaesthesiology*, *37*(12), 1126–1142. https://doi.org/10.1097/EJA.0000000000001371

Sathyavrdhan, G. S., & Kamath, S. S. (2024). Crystalloid Preloading versus Prophylactic Ephedrine Infusion for Prevention of Hypotension during Caesarean Section. *Journal of Obstetric Anaesthesia and Critical Care*, *14*(1), 33–36. https://doi.org/10.4103/JOACC.JOACC_29_23

Stickel, S., Gin-Sing, W., Wagenaar, M., & Gibbs, J. S. R. (2019). The practical management of fluid retention in adults with right heart failure due to pulmonary arterial hypertension. *European Heart Journal, Supplement*, *21*, K46–K53. https://doi.org/10.1093/eurheartj/suz207

Tiruneh, A., Kibret, S., & Abrar, M. (2021). Crystalloid Fluid Pre-loading or Co-loading for Prevention of Spinal Anesthesia Induced Hypotension at Gandhi Memorial Hospital, 2016 Addis Ababa, Ethiopia: Comparative Cohort Study. *Journal of Surgery and Anesthesia 1 J Surg Anesth*, *5*(2), 143.

Valverde, A. (2021). Fluid Resuscitation for Refractory Hypotension. *Frontiers in Veterinary Science*, *8*(March), 1–12. https://doi.org/10.3389/fvets.2021.621696

Wink, J. B. T. m. d. ; wouters, patrick f. (2019). Effects of Thoracic Epidural Anesthesia Regulation and Cardiac. *Thoracic Epidural Anesthesia and the Heart Medical*, *130*(3), 472–491.

Wu, J., Nie, J., Wang, Y., Zhang, Y., Wu, D., & Osemene, I. N. (2020). Relationship between saline infusion and blood pressure variability in non-critically patients with hypertension: A retrospective study. *Medicine (United States)*, *99*(35), 1–6. https://doi.org/10.1097/MD.0000000000021468