

Comparison of Regional and General Anesthesia in Eclampsia Patients Undergoing Caesarean Section: A Literature Review

Hijriah Syafitri¹, Mona Nulanda¹, Julia Hasir¹

¹Faculty of Medicine, Universitas Muslim Indonesia

*Corresponding Author: Hijriah Syafitri

Email: hijriahsyafitri86@gmail.com

Article Info

Article History:

Received July 23, 2026

Revised August 31, 2026

Accepted: September 29, 2026

Keywords:

Eclampsia, Cesarean section, regional anesthesia, Spinal anesthesia, General anesthesia, Maternal and neonatal outcomes.

Abstract

Eclampsia is a life-threatening obstetric emergency requiring prompt delivery and careful anesthetic management during cesarean section. This literature review aimed to compare the safety and effectiveness of regional anesthesia, particularly spinal anesthesia, with general anesthesia in patients with preeclampsia or eclampsia undergoing cesarean section. A narrative literature review was conducted using articles retrieved from PubMed, Google Scholar, ScienceDirect, and other relevant scientific sources. Articles published between 2018 and 2025 that examined maternal hemodynamic parameters and maternal or neonatal outcomes were included. Sixteen original studies with prospective, retrospective, observational, comparative, cohort, cross-sectional, and randomized designs were reviewed. Overall, spinal anesthesia was associated with more controlled intraoperative hemodynamics, fewer postoperative maternal complications, reduced intensive care requirements, shorter hospitalization, and better neonatal outcomes than general anesthesia. Although hypotension occurred in approximately 47–50% of patients receiving spinal anesthesia, it was generally transient and manageable with vasopressors. In contrast, general anesthesia was more frequently associated with hypertensive responses during laryngoscopy and intubation, pulmonary edema, renal complications, postoperative seizures, and delayed recovery. Neonates delivered under spinal anesthesia generally had higher first- and fifth-minute APGAR scores, lower rates of neonatal asphyxia, and reduced neonatal intensive care requirements. In conclusion, spinal anesthesia demonstrates a more favorable maternal and neonatal safety profile and should be considered the preferred technique when no contraindications are present. General anesthesia remains necessary in patients with severe thrombocytopenia, impaired consciousness, coagulation disorders, airway concerns, or clinical conditions requiring immediate airway control and rapid delivery.

Introduction

Eclampsia is one of the most serious complications of hypertensive disorders of pregnancy and remains an important cause of maternal and perinatal morbidity and mortality, particularly in low- and middle-income countries. Eclampsia is clinically characterized by the occurrence of generalized seizures and/or coma in a pregnant or postpartum woman with preeclampsia in the absence of another identifiable neurological cause (Kementerian Kesehatan Republik Indonesia, 2023). The development of eclampsia reflects severe systemic endothelial dysfunction, generalized vasoconstriction, increased vascular permeability, and impaired cerebral autoregulation. These pathophysiological changes can result in cerebral edema, intracranial hemorrhage, pulmonary edema, renal dysfunction, placental abruption, and other life-threatening complications (Al Dallal & Al-Jobury, 2024). Because both maternal and fetal conditions can deteriorate rapidly, eclampsia requires immediate stabilization, seizure control, blood pressure management, and timely termination of pregnancy. Consequently, the choice of

anesthetic technique during cesarean delivery becomes an important component of comprehensive maternal and fetal management.

Cesarean section may be required when rapid delivery is indicated, particularly when vaginal delivery is not appropriate, labor cannot be safely achieved within the required timeframe, or fetal and maternal conditions necessitate urgent intervention (Suprptomo, 2024). However, cesarean delivery in a patient with eclampsia presents substantial anesthetic challenges. These patients may have severe hypertension, altered intravascular volume, endothelial dysfunction, cerebral involvement, pulmonary edema, thrombocytopenia, and impaired consciousness. Such abnormalities increase the risk of significant hemodynamic instability during induction, surgery, and recovery. Therefore, the anesthetic technique should not be selected solely according to the urgency of delivery but should also consider neurological status, blood pressure control, coagulation profile, platelet count, airway condition, respiratory status, and fetal condition.

Two principal anesthetic approaches are used for cesarean section: regional anesthesia and general anesthesia. Regional anesthesia, particularly spinal anesthesia, produces surgical anesthesia through neuraxial blockade without requiring airway instrumentation (Kaushal & Haldar, 2020; Garg et al., 2022; Kamel et al., 2022). General anesthesia, in contrast, involves induction of unconsciousness followed by airway management, usually with endotracheal intubation. Historically, general anesthesia has been widely used in emergency cesarean delivery because of its rapid onset, reliable control of ventilation and airway, and suitability when immediate surgery is required (Leofirsta & Soeprptomo, 2022). These characteristics can be particularly relevant in eclampsia when the patient has decreased consciousness, ongoing seizures, severe respiratory compromise, or other conditions that make cooperation with regional anesthesia impossible.

Nevertheless, general anesthesia has several important disadvantages in patients with eclampsia. Laryngoscopy and endotracheal intubation can produce an intense sympathetic response, resulting in abrupt increases in blood pressure and heart rate (Min et al., 2026). In patients with impaired cerebral autoregulation, this acute hypertensive response may increase the risk of intracranial hemorrhage, cerebral edema, or other cerebrovascular complications. In addition, pregnancy-related airway edema and anatomical changes may make airway management more difficult and increase the risk of failed or traumatic intubation. General anesthesia may also be associated with greater maternal respiratory complications and postoperative recovery requirements, while exposure to anesthetic agents before delivery may influence neonatal adaptation.

Regional anesthesia has consequently gained increasing attention as an alternative approach for appropriately selected patients. By avoiding laryngoscopy and endotracheal intubation, regional anesthesia can reduce the sympathetic pressor response associated with airway manipulation and may provide more stable perioperative blood pressure control (Elawad et al., 2024). The technique also permits the mother to remain conscious during delivery and can provide effective postoperative analgesia (Aregawi et al., 2018). Importantly, available evidence in patients with preeclampsia suggests that spinal anesthesia can be performed with acceptable hemodynamic stability when appropriate monitoring and treatment of hypotension are available. However, regional anesthesia is not universally applicable. Sympathetic blockade may produce hypotension, which requires careful monitoring and prompt treatment to maintain adequate maternal cardiovascular stability and uteroplacental perfusion. Furthermore, severe thrombocytopenia or coagulation abnormalities may contraindicate neuraxial anesthesia because of the potential risk of spinal or epidural hematoma.

The choice between regional and general anesthesia therefore represents a balance between competing maternal and fetal risks rather than a simple preference for one technique. The available literature suggests that regional anesthesia may be associated with more favorable hemodynamic profiles and neonatal outcomes in appropriately selected patients, whereas general anesthesia remains necessary in specific clinical circumstances. Studies included in the present review have reported differences in blood pressure responses, vasopressor requirements, postoperative complications, intensive care requirements, hospital length of stay, APGAR scores, neonatal asphyxia, and other maternal and neonatal outcomes. At the same time, some studies have reported no significant differences in major maternal outcomes between the two techniques, indicating that the available evidence is not completely consistent.

This variation in findings is clinically important because anesthetic management in eclampsia must be individualized according to the patient's clinical condition (Overton et al., 2022; van Dyk et al., 2021; Kovacheva et al., 2024). Evidence regarding regional anesthesia may not be directly applicable to patients with severe thrombocytopenia, impaired consciousness, uncontrolled seizures, major respiratory compromise, or an immediate need for airway protection. Conversely, the potential hypertensive response and airway-related risks associated with general anesthesia require careful consideration in patients with severe neurological or cardiovascular involvement. Thus, an evidence-based comparison of the two techniques is necessary to clarify their respective benefits, risks, and clinical indications.

Given these considerations, a literature review provides an appropriate approach for synthesizing the available evidence concerning anesthetic management in eclamptic patients undergoing cesarean section. A comprehensive review of recent studies can provide an integrated assessment of intraoperative hemodynamic stability, maternal complications, postoperative recovery, and neonatal outcomes associated with regional and general anesthesia (Lim et al., 2018; Ahmadzadeh et al., 2025; Fu et al., 2025; Grace, 2026). The synthesis may also help identify clinical circumstances in which one technique may be more appropriate than the other while recognizing that patient-specific contraindications remain fundamental to anesthetic decision-making. Therefore, this literature review aims to compare regional and general anesthesia in eclamptic patients undergoing cesarean section, with particular emphasis on hemodynamic stability and maternal and neonatal outcomes.

Method

Research Design

This study employed a narrative literature review design to identify, examine, analyze, and synthesize published evidence concerning the use of regional and general anesthesia in patients with eclampsia undergoing cesarean section. A narrative review was selected because it allows findings from studies with different methodological designs, populations, clinical characteristics, and outcome measures to be integrated into a comprehensive clinical synthesis. The review specifically focused on comparing regional and general anesthesia about perioperative hemodynamic stability and maternal and neonatal outcomes. The review process consisted of literature identification, screening and selection of relevant articles, data extraction, comparative analysis, and narrative synthesis of the findings.

Literature Search Strategy

A systematic literature search was conducted using electronic databases and scientific search engines, including PubMed, Google Scholar, and ScienceDirect, as well as other relevant scientific sources. The search strategy was developed based on the main concepts of the review, namely eclampsia, cesarean section, regional anesthesia, and general anesthesia. The primary

search terms were “eclamptic patients undergoing cesarean section” and “comparison of regional and general anesthesia.” Additional combinations of these terms were used where necessary to identify studies addressing maternal hemodynamic responses, postoperative complications, and neonatal outcomes associated with the two anesthesia techniques. The literature search was restricted to publications within the 2018–2026 period. Articles published in either English or Indonesian were considered eligible. The search was conducted to identify studies that directly addressed the research question and provided sufficient information for comparison between regional and general anesthesia.

Data Sources and Data Type

The data analyzed in this literature review consisted of secondary data obtained from previously published scientific research. The sources included national and international journal articles, theses, e-books, and relevant textbooks. Priority was given to original research articles that reported clinical findings concerning anesthesia techniques in pregnant women with eclampsia or closely related hypertensive obstetric conditions undergoing cesarean section. The extracted information included the author and year of publication, study design, study population, sample size, type of anesthesia, and relevant clinical outcomes. Attention was given to hemodynamic parameters, including changes in blood pressure and heart rate, hypotension, vasopressor requirements, and perioperative hemodynamic stability. Maternal outcomes, such as postoperative complications, intensive care unit admission, postoperative recovery, length of hospital stay, and mortality, were also considered. Where reported, neonatal outcomes including Apgar scores, neonatal asphyxia, neonatal intensive care unit admission, and neonatal mortality were extracted for comparative analysis.

Inclusion and Exclusion Criteria

Studies were considered eligible if they met the following inclusion criteria: (1) involved pregnant women with eclampsia undergoing cesarean section; (2) directly compared regional anesthesia and general anesthesia; (3) were published between 2018 and 2026; (4) were written in Indonesian or English; and (5) were available as accessible full-text publications. Studies were excluded if they met one or more of the following criteria: (1) full-text articles were inaccessible or only abstracts were available; (2) the study topic was not relevant to the comparison of regional and general anesthesia in the context of cesarean delivery; and (3) the publication was a case report, editorial, or review article. These criteria were applied to maintain the relevance of the selected literature and ensure that the review primarily incorporated evidence derived from original research.

Literature Selection and Data Extraction

The article selection process was conducted in several stages. Initially, potentially relevant publications were identified through searches of the selected databases using the predetermined keywords. The titles and abstracts of retrieved publications were subsequently screened according to the inclusion and exclusion criteria. Articles considered potentially relevant were then assessed through full-text review. Publications that fulfilled all eligibility criteria were included in the final synthesis. Data from the eligible studies were extracted using a structured approach. The extracted variables included author, publication year, research design, sample size, study population, anesthesia technique, and principal outcomes. The extracted findings were subsequently compared across studies to identify similarities, differences, and recurring patterns in the effects of regional and general anesthesia.

Data Analysis and Synthesis

Because the included studies differed in their research designs, sample characteristics, clinical settings, and outcome measures, the findings were analyzed using a narrative synthesis approach rather than statistical meta-analysis. The results were organized according to the main clinical outcomes, including hemodynamic stability, maternal outcomes, and neonatal outcomes. The synthesis involved comparing the reported effects of regional and general anesthesia on perioperative blood pressure and heart rate, hypotension, vasopressor use, postoperative complications, intensive care requirements, recovery, length of hospitalization, and neonatal outcomes. Attention was given to the clinical circumstances in which each anesthesia technique was used, including the presence of contraindications to regional anesthesia and the need for rapid airway control. The findings were then integrated to provide an overall interpretation of the current evidence regarding the comparative use of regional and general anesthesia in eclamptic patients undergoing cesarean section.

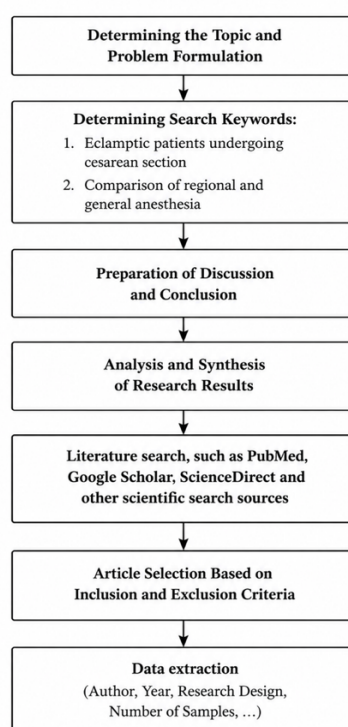


Figure 1. Research Flow of the Literature Review

Result And Discussion

To obtain a comprehensive overview of the comparison between regional and general anesthesia use in patients with preeclampsia and eclampsia undergoing cesarean section, we reviewed 16 scientific articles that met the inclusion criteria. These articles were published between 2018 and 2025 and comprised various research designs, including prospective comparative studies, prospective observational studies, prospective cohort studies, retrospective comparative studies, retrospective cross-sectional studies, interventional comparative studies, randomized prospective studies, and multicenter comparative cohort studies. All articles were original research discussing maternal and neonatal outcomes in patients with preeclampsia or eclampsia undergoing cesarean section using regional (spinal) or

general anesthesia. In general, these studies evaluated various clinical parameters, including intraoperative hemodynamic stability, changes in blood pressure and heart rate, vasopressor requirements, hypotension, maternal complications, the need for intensive care unit (ICU) care, length of stay, maternal mortality, APGAR scores, the incidence of neonatal asphyxia, the need for neonatal intensive care unit (NICU) care, and neonatal mortality. The synthesis of these studies indicates that regional anesthesia, particularly spinal anesthesia, tends to provide better hemodynamic stability, better maternal outcomes, and more optimal neonatal outcomes than general anesthesia. Although in certain clinical conditions, such as eclampsia with decreased consciousness, coagulation disorders, or emergencies requiring immediate termination of labor, general anesthesia remains the appropriate choice when indicated.

Table 1. Summary of Studies Included in the Literature Review

Year	Author	Title	Methods	Results	Conclusion
2020	Satpute SA, Nikam GK, Chauhan SD, Tarkase A, Deshmukh S.	<i>Comparative Study of General Anaesthesia and Spinal Anaesthesia in Severe Pre-eclampsia Patients Undergoing Emergency Caesarean Section</i>	Observational comparative study involving 100 patients with severe preeclampsia, comprising 50 patients receiving spinal anesthesia and 50 receiving general anesthesia. Maternal hemodynamics, APGAR scores, and maternal and neonatal complications were assessed.	Systolic, diastolic, and mean arterial blood pressures were higher during surgery in the general anesthesia group. First- and fifth-minute APGAR scores were higher in the spinal anesthesia group. Maternal and neonatal complications were not significantly different, although one maternal death occurred in the general anesthesia group.	Spinal anesthesia was associated with better hemodynamic stability and neonatal outcomes than general anesthesia in patients with severe preeclampsia undergoing cesarean section.
2022	Akbar RJA, Yas AK.	<i>Effect of Spinal Anaesthesia in the Pregnant</i>	Retrospective-prospective study involving 20 patients with preeclampsia	Systolic and diastolic blood pressure decreased following	Spinal anesthesia was considered a safe and effective

		<i>Women with Preeclampsia Undergoing Caesarean Section</i>	undergoing cesarean section under spinal anesthesia. Hemodynamic changes before and after spinal anesthesia were evaluated.	spinal anesthesia, while cardiac index improved after delivery. No significant hemodynamic complications were observed.	technique for preeclamptic patients undergoing cesarean section, with favorable hemodynamic stability.
2025	Fendiputra M, Lalenoh DC, Posangi I.	<i>Hemodynamic Profile and Pain Scale in Preeclampsia and Eclampsia Patients Undergoing Cesarean Section and Neonatal Outcomes (APGAR Score)</i>	Descriptive observational retrospective study using medical records of preeclampsia and eclampsia patients undergoing cesarean section between February 2023 and February 2025.	Spinal anesthesia with bupivacaine-fentanyl was more commonly used in preeclampsia, whereas general anesthesia was more frequently used in eclampsia. Perioperative hemodynamics were relatively stable, with no significant difference in postoperative pain scores between the two techniques.	The choice of anesthetic technique was determined according to the patient's clinical condition. Spinal anesthesia was more commonly used in preeclampsia, whereas general anesthesia was more frequently used in eclampsia.
2023	Belachew BG, Dessu BK, Demissie BW, et al.	<i>Comparison of the Hemodynamic Changes Between Preeclamptic and Normotensive</i>	Prospective cohort study comparing hemodynamic changes among preeclamptic and normotensive women undergoing	Hypotension occurred in 47% of the preeclampsia group compared with 74% of the normotensive group. Changes in	Spinal anesthesia produced relatively mild hemodynamic changes in preeclamptic patients and was considered safe for cesarean

		<i>Parturients Who Underwent Cesarean Section Under Spinal Anesthesia at North Showa Zone Public Hospitals, Oromia Region, Ethiopia: A Prospective Cohort Study</i>	cesarean section under spinal anesthesia.	systolic, diastolic, and mean arterial blood pressure were smaller among preeclamptic patients.	section with appropriate monitoring.
2024	Loh CJL, Qi Y, Sultana R, Tan CW, Sng BL, Yahaya Z.	<i>Hemodynamic Changes of Women with Preeclampsia Undergoing Spinal Anesthesia for Emergency Cesarean Section: A Prospective Observational Study</i>	Prospective observational study evaluating hemodynamic changes among women with preeclampsia undergoing emergency cesarean section under spinal anesthesia.	Approximately 50% of patients experienced hypotension following spinal anesthesia. However, changes in blood pressure, cardiac output, and stroke volume were temporary and returned toward stability during the postoperative period.	Spinal anesthesia was considered safe in preeclamptic patients when adequate perioperative hemodynamic monitoring was provided.
2024	Thakar UH, Panjabi GM, Desai D, Gami V.	<i>Comparison of Spinal Versus General Anesthesia for Cesarean Section in</i>	Prospective comparative observational study comparing spinal and general anesthesia in	General anesthesia was associated with increased blood pressure and heart rate during induction,	Spinal anesthesia may provide favorable maternal and neonatal outcomes in severe

		<i>Patients with Severe Preeclampsia</i>	patients with severe preeclampsia undergoing cesarean section.	whereas spinal anesthesia was more frequently associated with hypotension. Maternal and neonatal outcomes were more favorable in the spinal anesthesia group, while postoperative complications were more frequent in the general anesthesia group.	preeclampsia when there are no contraindications to regional anesthesia.
2024	Manaspurikar R, Kulkarni VV, Khadse M, Memon N.	<i>Comparative Study of Spinal Anaesthesia versus General Anaesthesia in Severe Preeclampsia Patients Undergoing Cesarean Section</i>	Interventional comparative study involving 60 patients with severe preeclampsia who were divided into general anesthesia and spinal anesthesia groups.	The spinal anesthesia group demonstrated more stable blood pressure and pulse, lower postoperative pain, fewer maternal complications, faster recovery, and higher neonatal APGAR scores than the general anesthesia group.	Spinal anesthesia was associated with favorable maternal and neonatal outcomes compared with general anesthesia in severe preeclampsia.
2018	Adugna Aregawi, Tsehay Terefe, Wossenyeleh Admasu,	<i>Comparing the Effect of Spinal and General Anaesthesia for Pre-</i>	Retrospective comparative cross-sectional study involving 170 women with	No significant differences were found in maternal mortality, length of	Spinal anesthesia was associated with better hemodynamic stability than

	Leulayehu Akalu.	<i>Eclamptic Mothers Who Underwent Caesarean Delivery in a Tertiary, Addis Ababa, Ethiopia</i>	preeclampsia undergoing cesarean section. Maternal outcomes, hemodynamic changes, length of hospital stay, postoperative complications, and ICU requirements were compared.	hospital stay, postoperative complications, or ICU requirements. However, postoperative blood pressure and pulse rate were higher in the general anesthesia group.	general anesthesia in preeclamptic patients undergoing cesarean section.
2024	Omer Abdalbagi Mohamed Elawad, Omayma Hassan Elamin, Areeg Izzeldin Ahmed Yousif, Gamal Abdalla Mohamed Ejaimi.	<i>Comparing General versus Spinal Anesthesia for Cesarean Section in Severely Pre-eclamptic Parturients</i>	Retrospective comparative cross-sectional study involving 80 women with severe preeclampsia undergoing emergency cesarean section, comprising 40 general anesthesia and 40 spinal anesthesia patients. Hemodynamics, vasopressor requirements, maternal complications, ICU requirements, and neonatal outcomes were assessed.	The spinal anesthesia group experienced a greater intraoperative reduction in blood pressure and more frequent vasopressor requirements. However, ICU admission and complications including acute kidney injury, pulmonary edema, and congestive heart failure were more frequent in the general anesthesia group.	Spinal anesthesia was associated with favorable maternal outcomes in severe preeclampsia when no contraindications to regional anesthesia were present.
2024	Haitham Bahaa Al Dallal, Bayan Thuban Al-Jobury.	<i>Anesthesia Type Outcome in Severe Pre-eclampsia with Caesarean Section</i>	Prospective comparative study involving patients with severe preeclampsia undergoing cesarean	First- and fifth-minute APGAR scores were significantly lower in the general anesthesia	Spinal anesthesia was associated with better neonatal outcomes and a lower risk of neonatal asphyxia,

			section. Maternal characteristics, neonatal APGAR scores, maternal mortality, and perinatal mortality were compared between anesthesia groups.	group. No significant differences were observed in maternal or perinatal mortality.	although anesthesia type was not associated with maternal or perinatal mortality.
2020	Kesumah A, Rustini R, Rasyid R.	<i>Comparison of Apgar Scores of Babies Born by Caesarean Section with General Anesthesia and Spinal Anesthesia from Eclamptic Mothers at Dr. M. Djamil Padang General Hospital</i>	Analytical cross-sectional study using medical record data from 63 women with eclampsia undergoing cesarean section. Thirty patients received spinal anesthesia and 33 received general anesthesia.	Neonatal asphyxia at the first minute occurred in 40% of the spinal group and 97% of the general anesthesia group. At the fifth minute, the rates were 16.7% and 54.5%, respectively. Differences in APGAR scores were statistically significant at both the first minute ($p < 0.01$) and fifth minute ($p = 0.02$).	Spinal anesthesia was associated with better neonatal APGAR outcomes than general anesthesia among eclamptic mothers undergoing cesarean section.
2022	Neme D, Aweke Z, Jemal B, Mulgeta H, Regasa T, Garolla G, Zemedkun A, Sintayhu A.	<i>Effect of Anesthesia Choice on Hemodynamic Stability and Fetomaternal Outcome of the</i>	Prospective multicenter comparative cohort study involving 266 patients with preeclampsia undergoing cesarean section under	Hemodynamic changes were relatively comparable between groups. Hospitalization was shorter in the spinal group (4.67	Spinal anesthesia was reported as a safe alternative to general anesthesia in preeclamptic patients, with favorable hemodynamic

		<i>Preeclamptic Patient Undergoing Cesarean Section</i>	spinal or general anesthesia.	vs. 5.92 days; $p = 0.024$). Maternal mortality within 48 hours was 2.6% in the spinal group compared with 14.8% in the general anesthesia group ($p = 0.027$), while neonatal mortality was 7.14% versus 16.6%, respectively.	outcomes and shorter hospitalization.
2020	Dawood M, Rasool N, Farooq N.	<i>Maternal and Fetal Outcome of Spinal versus General Anaesthesia in Pre-eclampsia Cases Undergoing Caesarean Section</i>	Retrospective comparative study involving 48 patients with severe preeclampsia: 18 received spinal anesthesia and 30 received general anesthesia. Maternal and neonatal outcomes, hemodynamic changes, mortality, hospital stay, and postoperative complications were assessed.	No significant differences were found in maternal mortality (5% vs. 7%; $p = 0.5$) or perinatal mortality (2.7% vs. 11.9%; $p = 0.15$). However, neonatal asphyxia was higher in the general anesthesia group (56% vs. 27%; $p = 0.0006$). ICU admission, postoperative seizures, acute renal failure, and length of hospital stay were also more frequent in the general	Spinal anesthesia was associated with better neonatal outcomes, fewer postoperative complications, fewer ICU admissions, and shorter hospitalization in severe preeclampsia when no contraindications were present.

				anesthesia group.	
2023	Rupwate K, Patil SS, Kesh RR.	<i>The Type of Anesthesia and Outcome in Preeclamptic Patients Undergoing Cesarean Section: An Observational Study</i>	Prospective observational clinical study involving 80 preeclamptic patients undergoing cesarean section. Thirteen patients received general anesthesia and 67 received spinal anesthesia. Hemodynamics, vasopressor requirements, ICU admission, ventilation, mortality, APGAR scores, NICU admission, and neonatal mortality were assessed.	Systolic and diastolic blood pressure increased significantly in the general anesthesia group. Vasopressor requirements were higher in the spinal group because of hypotension, which was managed with ephedrine or phenylephrine. ICU admission or ventilation was required in 61% of the general anesthesia group compared with none in the spinal group ($p < 0.001$). Neonatal outcomes and APGAR scores were better in the spinal group.	Spinal anesthesia was associated with favorable maternal and neonatal outcomes, although hypotension and vasopressor requirements were more common.
2023	Chadha H, Aggarwal R, Prasad R.	<i>To Evaluate the Maternal and Foetal Outcome in Parturients Undergoing Caesarean Section for Pre-</i>	Randomized prospective study involving 60 preeclamptic patients undergoing cesarean section. Thirty patients	Intraoperative systolic and diastolic blood pressure, MAP, and heart rate were lower and more stable in the spinal anesthesia	Spinal anesthesia was associated with better maternal and neonatal outcomes, improved intraoperative hemodynamic stability, lower

		<i>Eclampsia Under Spinal and General Anaesthesia : A Randomised Prospective Study</i>	received spinal anesthesia and 30 received general anesthesia. Hemodynamic variables, APGAR scores, ICU requirements, seizures, pulmonary edema, and postoperative recovery were assessed.	group ($p < 0.05$). First-minute APGAR scores were higher in the spinal group. ICU requirements were higher in the general anesthesia group (53% vs. 13%; $p = 0.002$), while seizures, pulmonary edema, and delayed recovery were also more frequent.	ICU requirements, and better neonatal APGAR scores.
2024	Singariya G, Yuvaraj S, Kamal M, Garg M, Chhabra A, Khatri C.	<i>Comparison of Hemodynamic Changes in Normotensive and Preeclamptic Parturients Undergoing Cesarean Section Under Spinal Anesthesia: A Prospective Observational Study</i>	Prospective observational study involving 100 pregnant women aged 18–35 years undergoing elective cesarean section under spinal anesthesia. Fifty were normotensive and 50 had preeclampsia. Hemodynamic variables, phenylephrine requirements, umbilical artery pH, and APGAR scores were assessed.	Decreases in DBP and MAP after spinal anesthesia were greater in the normotensive group than in the preeclampsia group. Phenylephrine requirements were also higher among normotensive women ($95.16 \pm 41.54 \mu\text{g}$ vs. $68.42 \pm 31.14 \mu\text{g}$; $p < 0.001$). Umbilical artery pH and APGAR scores did not differ significantly	Preeclamptic women undergoing cesarean section under spinal anesthesia experienced less hypotension and required fewer vasopressors than normotensive women, without adverse effects on neonatal outcomes.

				between groups.	
--	--	--	--	--------------------	--

Comparison of Regional and General Anesthesia in Eclamptic Patients Undergoing Cesarean Section

Eclampsia is a life-threatening obstetric complication characterized by the unexplained onset of seizures during pregnancy, labor, or the postpartum period in patients with preeclampsia. Cesarean section is the preferred delivery method in most cases of eclampsia because medical management with magnesium sulfate and antihypertensives does not always halt disease progression. In this context, the choice of anesthetic technique is a critical clinical decision, balancing maternal and fetal safety while addressing the complex pathophysiological changes of eclampsia.

The medical literature demonstrates a paradigm shift in anesthetic management of eclamptic patients over the past two decades. Historically, general anesthesia was considered the technique of choice in this population because it was believed to provide better airway control and hemodynamic stability. However, accumulating clinical evidence from prospective and retrospective studies indicates that spinal anesthesia, when performed with proper technique and adequate monitoring, is not only equivalent but even superior to general anesthesia in terms of maternal and neonatal outcomes (Satpute, 2020). This changing view is reflected in recommendations from various international anesthesiology organizations that increasingly advocate for the use of regional anesthesia as the first choice in patients with preeclampsia and eclampsia who have no contraindications (Akbar & Yas, 2022).

The hemodynamic characteristics of eclamptic patients show a different profile than those of preeclamptic patients. Eclamptic patients have higher basal blood pressure and a more reactive hemodynamic response to anesthetic stimuli. Prospective studies have shown that systolic, diastolic, and mean arterial pressure (MAP) in patients with severe preeclampsia experience less change than in normotensive patients after spinal anesthesia (Fendiputra et al., 2025). This phenomenon has been referred to as "relative sparing" in preeclamptic patients, where their chronic vasoconstriction provides protection against extreme hypotension after spinal blockade.

The use of spinal anesthesia in eclamptic patients is also influenced by the presence or absence of contraindications to regional anesthesia. Major contraindications include severe thrombocytopenia (platelet count $<70,000/\mu\text{L}$), unstable mental status, and significant hemodynamic instability (Manaspurikar et al., 2024). In these situations, general anesthesia is a safer option because it provides better airway control, maintains cerebral perfusion, and allows for more rapid management of acute hypertension through intravenous agents.

Intraoperative hemodynamic changes show different patterns between the two anesthetic techniques. A prospective comparative study involving 60 patients with severe preeclampsia showed that general anesthesia caused a significant increase in blood pressure and heart rate during induction, with an average increase in MAP reaching 20-30% from baseline. This hypertensive response occurs because the stimuli of laryngoscopy and intubation trigger massive catecholamine release from the already hyperreactive sympathetic system in eclamptic patients. In contrast, spinal anesthesia causes a more measurable decrease in blood pressure, although approximately 47-50% of patients experience hypotension requiring vasopressor intervention.

A retrospective cross-sectional comparison of 80 patients with severe preeclampsia showed that although the spinal anesthesia group experienced a greater intraoperative decrease in blood

pressure, the general anesthesia group had a less well-controlled hypertension profile, ultimately increasing the risk of cardiovascular complications in the postoperative period. These data suggest that the more extreme hemodynamic response of general anesthesia does not provide clinical benefit and instead increases physiological stress in mothers already experiencing significant hemodynamic regulation impairment.

Maternal complications showed significant differences between the two groups. A comparative retrospective study of 48 patients with severe preeclampsia found that although there was no significant difference in maternal mortality between spinal anesthesia (5%) and general anesthesia (7%), the general anesthesia group showed a significantly higher rate of postoperative complications, including ICU requirements (17%), postoperative seizures (10%), and acute renal failure (13%). These differences are likely related to the greater stress response and longer recovery duration of general anesthesia, which exacerbate the already complex pathophysiological conditions of eclampsia (Thakar et al., 2024).

Hemodynamic stability in the postoperative period demonstrates the superiority of spinal anesthesia. A comparative retrospective study of 170 preeclamptic patients undergoing cesarean section found that postoperative blood pressure and heart rate were higher in the general anesthesia group than in the spinal anesthesia group, although both groups showed gradual stabilization (Aregawi et al., 2018). The higher blood pressure in the general anesthesia group in the early postoperative period suggests that the stimulus from general anesthesia produces longer-lasting residual effects on the sympathetic nervous system. This may be detrimental, as sustained hypertension increases the risk of cerebrovascular complications in eclamptic patients.

Neonatal Apgar scores showed the most consistent and significant difference between the two anesthetic techniques. A cross-sectional analytical study of 63 eclamptic patients undergoing cesarean section found a dramatic difference in the incidence of neonatal asphyxia: within the first minute, asphyxia occurred in 40% of neonates in the spinal anesthesia group compared to 97% in the general anesthesia group.(22) This difference narrowed by the fifth minute (16.7% vs. 54.5%), indicating that neonates in the general anesthesia group experienced more profound asphyxia and required a longer recovery time. The definition of asphyxia in this study used an Apgar score <7, which is the international standard for neonatal depression requiring active intervention.

The fetal concentration of volatile anesthetics depends not only on the duration of exposure but also on several other factors, including: (1) increased placental blood flow during surgery due to stimulus and stress, (2) the concentration gradient between maternal and fetal blood, (3) the solubility of the agent in fetal tissues, and (4) the capacity of the fetal lung to extract the volatile agent. All of this results in volatile agent concentrations in fetal blood and tissues that exceed maternal alveolar concentrations in some cases, creating significant neonatal depression.

In contrast, spinal anesthesia with bupivacaine results in minimal placental crossing because bupivacaine is highly bound to plasma proteins (90-95%) and has limited lipophilicity (pKa 8.1). Only the free fraction of bupivacaine crosses the placenta, and this fraction is very small (approximately 5-10% of the total). Fentanyl, which is sometimes added, also has limited placental crossing due to the small dose (10-15 mcg), far below the dose used for intrauterine analgesia, and its rapid metabolism by fetal lung tissue.

Improved neonatal outcomes with spinal anesthesia are not limited to APGAR scores alone. A prospective observational study found that 77.6% of infants in the spinal anesthesia group experienced uncomplicated outcomes compared to only 30.7% in the general anesthesia group.

12 This difference reflects not only better APGAR scores but also a lower need for NICU (Neonatal Intensive Care Unit) admission in the spinal anesthesia group. These infants who did not require NICU admission did not experience complications such as severe asphyxia, aspiration pneumonia, or respiratory distress requiring mechanical ventilation.

Spinal anesthesia demonstrates a superior safety profile in eclamptic patients undergoing cesarean section, based on comparative evidence from the literature. This safety profile extends beyond hemodynamic stability to the prevention of broader maternal and neonatal complications.

First, although hypotension is a common side effect of spinal anesthesia (occurring in 47-50% of patients), it is predictable, can be measured in real time through continuous blood pressure monitoring, and can be effectively managed with vasopressors (ephedrine 5-10 mg IV or phenylephrine 50-100 mcg IV) Thakar et al. (2024). Prospective observational studies have shown that vasopressor requirements in spinal anesthesia patients can be significantly managed with the same medications used to treat postoperative hypotension, creating a logical and easily learned management continuum for the anesthesia team. In contrast, hypertension during general anesthesia requires intervention with antihypertensive agents that can have more significant side effects, such as rebound hypotension when the stimulus is reduced, bradycardia that can compromise cardiac output, and complex drug interactions.

Second, spinal anesthesia eliminates the need for airway manipulation through laryngoscopy and endotracheal intubation. In eclamptic patients with cerebral edema and increased intracranial pressure, stimulation from laryngoscopy and intubation can further increase intracranial pressure through sympathetic reflex mechanisms and increased cerebral venous pressure, and in extreme situations, can precipitate seizures or stroke (Thakar et al., 2024). By avoiding airway manipulation, spinal anesthesia provides superior neuroprotection. Furthermore, the need for deeper analgesia (greater depth of anesthesia) under general anesthesia to prevent a response to laryngoscopy also increases neonatal depression.

Third, spinal anesthesia reduces the duration of anesthetic exposure for both mother and baby. Compared with general anesthesia, which requires continuous sedation throughout the operation (averaging 30-45 minutes), spinal anesthesia requires only a rapid induction of block (30-60 seconds for onset of sensory block), after which anesthesia is maintained by local anesthetic block for a predictable duration (2-3 hours for 10-12 mg bupivacaine) without the need for additional agents. This reduction in duration translates to lower rates of neonatal depression and faster maternal recovery because there is no long duration of sedation that needs to be reversed after surgery is complete.

Fourth, spinal anesthesia avoids the use of volatile agents. Volatile agents such as sevoflurane have been shown to have teratogenic effects on the reproductive system based on animal model studies, although their clinical significance in humans remains debated. In eclamptic patients with endothelial dysfunction and a significant vasoconstrictor-vasodilator imbalance, the addition of volatile agents may exacerbate this imbalance through their direct vasodilatory effects, which can lead to more severe hypotension (Loh et al., 2024).

From an efficacy perspective, spinal anesthesia demonstrates superior performance in achieving anesthetic goals. First, spinal anesthesia provides superior analgesia during surgery. The combination of bupivacaine with opioids (fentanyl 10-15 mcg or morphine 0.1-0.2 mg) produces a high-quality block with minimal somatic pain stimulation (from skin incision and organ manipulation) and visceral pain stimulation (from uterine manipulation), which can

trigger a stress response and hypertension. This translates into a lower stress response (lower catecholamine and cortisol levels) and better hemodynamic stability.

Second, spinal anesthesia allows for a more rapid postoperative discharge. Patients receiving spinal anesthesia can typically be transferred from the recovery room within 2-3 hours after the block wears off, while patients under general anesthesia require longer monitoring due to the higher risk of residual complications from general anesthesia (aspiration, delayed emergence from sedation, residual respiratory depression) Neme et al. (2023).

Third, spinal anesthesia has a high success rate in the obstetric population. Based on experience at various obstetric centers, spinal anesthesia has a first-pass success rate of over 95% in obstetric patients when performed by trained operators (Fendiputra et al., 2025). This high success rate reduces the need for conversion to general anesthesia (which occurs in <5% of patients) and the side effects of multiple attempts at neuraxial blockade, which can increase tissue trauma, the risk of spinal hematoma, and patient discomfort.

Fourth, spinal anesthesia can be used in a variety of clinical situations. Although there are clear contraindications, spinal anesthesia can be tailored to various scenarios: in patients with mild coagulopathy, it can be considered with informed consent after consultation with a hematologist; In patients with very high blood pressure, a combined spinal-epidural technique can be used to further modulate the onset of blockade and provide management flexibility; in patients with encephalopathy, a lower dose of bupivacaine with a higher opioid can be used to minimize neuraxial effects on the already compromised spinal cord.

Conclusion

Spinal anesthesia with bupivacaine-fentanyl is more commonly used in preeclampsia, while general anesthesia is used in eclampsia with spinal contraindications (thrombocytopenia <70,000/ μ L, altered mental status, hemodynamic instability). Eclamptic patients show "relative sparing" with minimal hemodynamic changes after spinal anesthesia. The choice of pharmacological agents also differs: spinal anesthesia uses low-dose bupivacaine + fentanyl, while general anesthesia uses etomidate or ketamine (instead of propofol) for better hemodynamic stability. Spinal anesthesia has shown significant advantages in maternal outcomes. The 48-hour maternal mortality rate is lower with spinal anesthesia (2.6% vs. 14.8%; 82% lower). Although hypotension occurs in 47-50% of patients with spinal anesthesia, this change is transient and can be managed with vasopressors, in contrast to general anesthesia, which causes a 20-30% increase in MAP that is difficult to control. Postoperative complications were fewer with spinal anesthesia (seizures, AKI, pulmonary edema), hospital stays were shorter (4.67 vs. 5.92 days), and ICU requirements were significantly lower (13% vs. 53%). The differences in neonatal outcomes were most dramatic. First-minute Apgar scores were significantly higher with spinal anesthesia (8.70 vs. 4.00; $p < 0.001$), with a similar pattern at the fifth minute (9.66 vs. 5.00). Neonatal asphyxia was significantly lower with spinal anesthesia (40% vs. 97%), as was the fifth minute (16.7% vs. 54.5%). 77.6% of infants in the spinal anesthesia group experienced an uncomplicated outcome compared to only 30.7% with general anesthesia⁸. Neonatal mortality was also lower with spinal anesthesia (7.14% vs. 16.6%). The mechanism of neonatal depression in general anesthesia is due to rapid placental crossing of volatile agents with an exposure duration of 30-45 minutes resulting in high fetal concentrations, while bupivacaine has minimal placental crossing due to high plasma protein binding (90-95%). Spinal anesthesia demonstrates a superior safety and effectiveness profile compared to general anesthesia in eclamptic patients undergoing cesarean section. This evidence is supported by 83% of studies concluding that spinal anesthesia is superior. The superior safety profile of spinal anesthesia is due to: (1) predictable hypotension and

management with standard vasopressors; (2) avoidance of intubation, which can increase dangerous intracranial pressure; (3) reduced duration of anesthetic drug exposure for the mother and baby; (4) avoidance of harmful volatile agents. The superior effectiveness profile is due to: (1) superior analgesia during surgery; (2) a first-pass success rate of >95%; and (3) faster recovery.

References

- Ahmadzadeh, S., Duplechin, D. P., Bailey, P. D., Duplechan, D. T., Enache, A. J., Moore, P., & Shekoohi, S. (2025). Anesthetic management for delivery in parturients with heart disease: a narrative review. *Biomedicines*, 13(7), 1736.
- Akbar, R. J. A., & Yas, A. K. (2022). Effect of spinal anaesthesia in pregnant women with preeclampsia. *World Bulletin of Public Health*, 12, 19–24.
- Al Dallal, H. B., & Al-Jobury, B. T. (2024). Anesthesia type outcome in severe pre-eclampsia with caesarean section. *Al-Qadisiyah Medical Journal*, 7(1), 93–97. <https://doi.org/10.54133/ajms.v7i1.1067>
- Aregawi, A., Terefe, T., Admasu, W., & Akalu, L. (2018). Comparing the effect of spinal and general anaesthesia for pre-eclamptic mothers who underwent caesarean delivery in a tertiary, Addis Ababa, Ethiopia. *Ethiopian Journal of Health Sciences*, 28(4), 443–450. <https://doi.org/10.4314/ejhs.v28i4.10>
- Aregawi, A., Terefe, T., Admasu, W., & Akalu, L. (2018). Comparing the effect of spinal and general anaesthesia for pre-eclamptic mothers who underwent caesarean delivery in a tertiary, Addis Ababa, Ethiopia. *Ethiopian Journal of Health Sciences*, 28(4), 443–450.
- Basith, A., & Adnan, M. L. (2026). Anesthesia management in patient with eclampsia and HELLP syndrome: A case report. *Jurnal Ilmiah Kedokteran Wijaya Kusuma*, 15(1), 77–83. <https://doi.org/10.30742/jikw.v15i1.4955>
- Belachew, B. G., Kasahun, B., Demissie, B. W., Sintayhu, A., Dendir, G., Ali, A., et al. (2023). Comparison of the hemodynamic changes between preeclamptic and normotensive parturients who underwent cesarean section under spinal anesthesia at North Showa Zone public hospitals, Oromia Region, Ethiopia, 2022: A prospective cohort study. *BMC Anesthesiology*, 23(1), 1–12.
- Chadha, H., Aggarwal, R., & Prasad, R. (2023). To evaluate the maternal and foetal outcome in parturients undergoing caesarean section for pre-eclampsia under spinal and general anaesthesia: A randomised prospective study. *Archives of Anesthesiology and Critical Care*, 9(4), 304–309.
- Dawood, M., Rasool, N., & Farooq, N. (2020). Maternal and fetal outcome of spinal versus general anaesthesia in pre-eclampsia cases undergoing caesarean section. 24(2), 1669–1675.
- Elawad, O. A. M., Elamin, O. H., Yousif, A. I. A., & Ejaimi, G. A. M. (2024). Comparing general versus spinal anesthesia for cesarean section in severely pre-eclamptic parturients. *Sudan Journal of Medical Sciences*, 19(4), 473–481.
- Elawad, O. A. M., Elamin, O. H., Yousif, A. I. A., & Ejaimi, G. A. M. (2024). Comparing general versus spinal anesthesia for cesarean section in severely pre-eclamptic parturients. *Sudan Journal of Medical Sciences*, 19(4), 473–481.

- Fadhilah, N., & Widyastuti, R. (2022). Eklampsia. *Continuing Medical Education*.
- Fendiputra, M., Lalenoh, D. C., & Posangi, I. (2025). Profil hemodinamik dan skala nyeri pada pasien preeklampsia dan eklampsia yang dilakukan seksio sesarea serta luaran neonatal (skor APGAR). *Journal of Comprehensive Science*, 4(12), 3340–3355.
- Fu, G., Xu, L., Chen, H., & Lin, J. (2025). State-of-the-art anesthesia practices: a comprehensive review on optimizing patient safety and recovery. *BMC surgery*, 25(1), 32.
- Garg, B., Ahuja, K., & Sharan, A. D. (2022). Regional anesthesia for spine surgery. *JAAOS-Journal of the American Academy of Orthopaedic Surgeons*, 30(17), 809-819.
- Grace, E. (2026). Maternal Outcomes Following Different Anesthetic Techniques for Emergency Cesarean Delivery.
- Kamel, I., Ahmed, M. F., & Sethi, A. (2022). Regional anesthesia for orthopedic procedures: What orthopedic surgeons need to know. *World journal of orthopedics*, 13(1), 11.
- Katsi, V., Svigkou, A., & Dima, I. (2024). Diagnosis and treatment of eclampsia. *Journal of Cardiovascular Development and Disease*, 11.
- Kaushal, A., & Haldar, R. (2020). Regional anesthesia in neuroanesthesia practice. *Discoveries*, 8(2), e111.
- Kementerian Kesehatan Republik Indonesia. (2023). *Pedoman nasional pelayanan kedokteran: Tatalaksana gangguan hipertensi pada kehamilan*.
- Kesumah, A., & Rustini, R. (2020). Perbandingan nilai APGAR bayi yang lahir melalui sectio caesarea dengan anestesia umum dan anestesia spinal. *Jurnal Kesehatan Andalas*, 9(1), 107–112.
- Kovacheva, V. P., Venkatachalam, S., Pfister, C., & Anwer, T. (2024). Preeclampsia and eclampsia: Enhanced detection and treatment for morbidity reduction. *Best Practice & Research Clinical Anaesthesiology*, 38(3), 246-256.
- Leofirsta, H., & Soeprapto, R. T. H. (2022). Manajemen anestesi pada ibu hamil dengan preeklampsia berat, sistemik lupus eritematosus dan sindroma antifosfolipid [Anesthesia management in woman with severe preeclampsia, systemic lupus erythematosus and antiphospholipid syndrome]. *Jurnal Anestesi Obstetri Indonesia*, 5, 103–111. <https://doi.org/10.47507/obstetri.v5i3.103>
- Lim, G., Facco, F. L., Nathan, N., Waters, J. H., Wong, C. A., & Eltzschig, H. K. (2018). A review of the impact of obstetric anesthesia on maternal and neonatal outcomes. *Anesthesiology*, 129(1), 192.
- Loh, C. J. L., Qi, Y., Sultana, R., Tan, C. W., Sng, B. L., & Yahaya, Z. (2024). Hemodynamic changes of women with preeclampsia undergoing spinal anesthesia for emergency cesarean section: A prospective observational study. *Bali Journal of Anesthesiology*, 8(3), 164–168.
- Min, W. K., Jin, S., Lee, Y., Cho, J., Kim, S., & Choi, E. (2026). Association of pre-eclampsia with intraoperative hemodynamics and postoperative complications in cesarean delivery under general anesthesia: A retrospective cohort study. *Journal of Clinical Medicine*, 15, 1–14.

- Neme, D., Aweke, Z., Jemal, B., Mulgeta, H., Regasa, T., Garolla, G., et al. (2022). Effect of anesthesia choice on hemodynamic stability and fetomaternal outcome of the preeclamptic patient undergoing cesarean section. *Annals of Medicine and Surgery*, 77, 103654.
- Overton, E., Tobes, D., & Lee, A. (2022). Preeclampsia diagnosis and management. *Best practice & research Clinical anaesthesiology*, 36(1), 107-121.
- Rupwate, K., Patil, S., & Kesh, R. (2023). The type of anesthesia and outcome in preeclamptic patients undergoing cesarean section: An observational study. *Medical Journal of Dr. DY Patil Vidyapeeth*, 16(2), 178–185.
- Satpute, S. A. (2020). Comparative study of general anaesthesia and spinal anaesthesia in severe pre-eclampsia patients undergoing emergency caesarean section in tertiary care centre. *MedPulse International Journal of Anesthesiology*, 15(3), 87–92.
- Singariya, G., Yuvaraj, S., Kamal, M., Garg, M., Chhabra, A., & Khatri, C. (2024). Comparison of hemodynamic changes in normotensive and preeclamptic parturients undergoing cesarean section under spinal anesthesia. *Indian Anaesthesia Forum*, 25(1), 58–59.
- Sinha, D. K., Verma, S. K., & Kumar, H. (2025). Comparative study of general anaesthesia and spinal anaesthesia in pre-eclampsia patients undergoing emergency caesarean section. *International Journal of Scientific Research*, 16(11), 494–502.
- Suprptomomo, R. (2024). Seksio sesarea emergensi dengan regional anestesi pasien G1P0A0, preeklamsi berat (PEB), ketuban pecah dini (KPD), ascites permagna, hipoalbumin, suspek sindroma nefrotik [Emergency caesarean section with regional anesthesia in a patient with severe preeclampsia, premature rupture of membranes, massive ascites, hypoalbuminemia, and suspected nephrotic syndrome]. *Jurnal Anestesi Obstetri Indonesia*, 8(2), 111–119. <https://doi.org/10.47507/obstetri.v8i2.202>
- Thakar, U. H., Panjabi, G. M., & Gami, D. D. (2024). Comparison of spinal versus general anesthesia for cesarean delivery in patients with severe preeclampsia. *Journal of Medical Sciences*, 7(6), 1044–1048.
- van Dyk, D., Dyer, R. A., & Fernandes, N. L. (2021). Preeclampsia in 2021—a perioperative medical challenge for the anesthesiologist. *Anesthesiology Clinics*, 39(4), 711-725.
- Zagrodnik, E., Szczuko, M., & Surówka, A. (2026). Hemodynamic changes during cesarean section under spinal anesthesia in normotensive and hypertensive pregnant women—A narrative review. *Journal of Clinical Medicine*, 1–18. <https://doi.org/10.3390/jcm15062162>