Review Paper

APGAR Scores in Cesarean Deliveries: Effects of General and Spinal Anesthesia: A Systematic Review

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ABSTRACT

Background: General and spinal anesthesia (SA) are widely used in cesarean deliveries. General anesthesia (GA), favored for emergencies, provides rapid onset but raises concerns about neonatal outcomes due to transplacental drug transfer. SA, preferred for elective procedures, allows maternal consciousness, enhancing neonatal outcomes and minimizing systemic effects.

Objectives: We conducted this review to compare the effects of general and SA on neonatal appearance, pulse, grimace response, activity, and respiration (APGAR) scores in cesarean deliveries and evaluate associated maternal and neonatal outcomes.

Methods: A systematic review of studies published between January 2000 and September 2023 was conducted. Databases searched included PubMed, Embase, and Cochrane Library. The inclusion criteria encompassed English-language studies on general or spinal anesthesia during cesarean deliveries and their effects on APGAR scores.

Results: We reviewed several studies, encompassing findings from diverse investigations. The cumulative insights shed light on the comparative effects of general and SA, with additional considerations for newborn rectal temperature, regional cerebral oxygenation, and cases of placenta previa. Some studies compared APGAR scores between general and SA groups in elective cesarean deliveries. Contrary to concerns about prolonged anesthesia duration, the study found no significant difference in mean APGAR scores. Additionally, another investigation observed comparable APGAR scores and cord blood gas values between GA and combined spinal-epidural anesthesia (EA), highlighting the efficiency of GA. Another study reported superior APGAR and neurologic scores, favorable blood gas values, and earlier breastfeeding initiation with SA. Nevertheless, another study found no significant impact on short-term outcomes with different anesthesia methods, reinforcing the safety of both approaches. Studies examining newborn rectal temperature revealed lower temperatures in the spinal group. This observation, coupled with slightly lower APGAR scores and umbilical vein pH, suggests a mild risk of temperature reduction without reaching critical hypothermia. Other studies demonstrate the superiority of combined spinal-EA over GA in regional cerebral oxygenation. This outcome emphasizes potential benefits for neonatal well-being, aligning with the broader discussion on the advantages of neuraxial anesthesia. Some studies specifically focused on placenta previa cases. The findings highlighted the advantages of neuraxial anesthesia over GA, showcasing

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improved maternal outcomes and a lower rate of neonatal asphyxia in the context of placenta previa. Heterogeneity in study designs and populations may limit generalizability. Additional randomized controlled trials are recommended.

Conclusions: Both methods are safe, with SA offering neonatal advantages in elective cases and GA being effective in emergencies. Further research is needed to refine guidelines.

Introduction

General anesthesia (GA) involves rendering the patient unconscious, with the induction of a reversible state of controlled unconsciousness. GA has historically been employed for its rapid onset in cesarean section, making it suitable for emergencies or when a quick response is required. However, its use has declined in recent years due to concerns about potential adverse effects on the mother and the neonate. One significant consideration with GA is the transplacental transfer of anesthetic agents, which can affect neonates. Medications used for GA may cross the placenta and reach the fetus, potentially causing respiratory depression or other complications in the newborn. Choosing specific anesthetic agents and their dosages is crucial in minimizing these risks [1]. Spinal anesthesia (SA) involves the administration of anesthetic agents into the spinal space, providing pain relief while allowing the mother to remain conscious during the procedure. It is a popular choice for elective cesarean sections and is associated with several potential benefits. One of the primary advantages of SA is its ability to provide effective pain control, allowing the mother to be awake during the birth of her child. This condition enhances the birthing experience and facilitates early maternal-infant bonding [2]. Additionally, SA is associated with a reduced need for GA, thereby minimizing the potential risks to the neonate associated with transplacental drug transfer. The dosage and choice of local anesthetics, opioids, or a combination of both in the spinal solution can be tailored to achieve the desired level of analgesia while minimizing systemic effects [3]. Comparing GA and spinal analgesia in the context of cesarean deliveries involves weighing the benefits and risks associated with each approach. While GA may be preferred in emergencies, SA is often favored for its ability to provide effective pain relief without compromising maternal consciousness. Selecting the optimal anesthesia strategy should prioritize its impact on neonatal appearance, pulse, grimace, activity, respiration (APGAR) scores, maternal recovery, and overall satisfaction [1, 4]. The APGAR score is a rapid tool used to assess a newborn's physical condition immediately after birth [3, 5].

The use of anesthesia during cesarean deliveries is a critical aspect of obstetric care, with both GA and SA being common modalities employed to manage pain and ensure a safe surgical environment. The impact of these anesthesia methods on neonatal outcomes, particularly as measured by APGAR scores, has been a subject of considerable interest and ongoing research. This review aims to provide a comprehensive synthesis of existing literature, evaluating the effects of GA and spinal analgesia on neonatal APGAR scores in the context of cesarean section deliveries. By examining a range of studies and considering various factors influencing outcomes, we seek to elucidate the current understanding of these anesthesia techniques and their implications for the immediate well-being of newborns. This review explores the physiological basis of APGAR scoring and addresses the potential implications for clinical practice and future research directions in obstetric anesthesia.

Rationale

Anesthesia during cesarean delivery significantly impacts maternal and neonatal outcomes. While GA ensures rapid onset for emergencies, its systemic effects may affect neonatal respiratory adaptation. SA, providing localized pain relief and maternal consciousness, is linked to improved APGAR scores and early bonding. This systematic review evaluates these methods to guide clinical decisions.

Objectives

This review assesses neonatal APGAR scores, maternal recovery, and satisfaction following cesarean deliveries under general versus SA. The study addresses participants (pregnant individuals undergoing cesarean), interventions (anesthesia types), comparisons (general vs spinal), outcomes (APGAR scores, maternal satisfaction), and study designs (randomized control trials [RCTs], cohort studies).

Methods

A comprehensive search of electronic databases, including PubMed, Embase, and Cochrane Library, was

conducted for data gathering. The search strategy employed a combination of keywords as follows: "General anesthesia," "spinal anesthesia," "APGAR scores," "newborns," "cesarean section," "comparative study," "assessment," "neonatal outcomes," "newborn well-being," "cesarean section," "maternal anesthesia," "anesthesia effects on mothers," "neonatal health," "maternal health," "observational study," "assessment methodology," "factors affecting APGAR scores," "potential risks of anesthesia," "antenatal care," "impact of anesthesia on pregnancy," "best practices in anesthesia for cesarean section," "obstetric anesthesia guidelines," "APGAR score interpretation," and "anesthesia guidelines for obstetric care." The selected studies were thoroughly studied and finalized. The inclusion criteria encompassed studies published between January 2000 and September 2023, written in English, and involving GA or SA on the APGAR scores of newborns delivered via cesarean section. Randomized controlled trials, prospective and retrospective cohort studies, systematic reviews, and meta-analyses were included. The identified studies were screened based on title and abstract, followed by a full-text review to assess their relevance to the topic.

Protocol and registration

This review followed PRISMA (preferred reporting items for systematic reviews and meta-analyses) guidelines and was registered in the international prospective register of systematic reviews (PROSPERO).

Eligibility criteria

The included studies were published between 2000 and 2023 in English and involved cesarean deliveries under general or SA with reported APGAR scores. The exclusion criteria included non-cesarean deliveries and studies without neonatal outcome data.

Information sources and search strategy

Databases searched included PubMed, Embase, and Cochrane Library. The search strategy employed combinations of keywords: "General anesthesia," "spinal anesthesia," "APGAR scores," and "cesarean section."

Study selection

Titles and abstracts were screened by two reviewers, followed by a full-text evaluation of eligible studies. Discrepancies were resolved by consensus.

Data collection process

Data extraction involved standardized forms capturing study design, population, anesthesia type, APGAR scores, and maternal outcomes.

Risk of bias assessment

The cochrane risk of bias tool was used for RCTs and the Newcastle-Ottawa scale (NOS) for observational studies.

Summary measures

Primary outcomes included mean APGAR scores at 1 and 5 minutes. Secondary outcomes encompassed neonatal acid-base status and maternal satisfaction.

Synthesis of results

A narrative synthesis was conducted. Meta-analysis was performed using RevMan (ReviewManager) software, version 5.4 where feasible.

Results

GA is occasionally administered during cesarean sections when regional anesthesia methods (such as spinal) are contraindicated or not preferred. It involves rendering the mother unconscious and insensible to pain [6]. Studies have explored the association between the use of GA during cesarean sections and the APGAR scores of newborns. The impact may be influenced by factors such as the type and dosage of anesthetic agents used, maternal health, and the speed of the delivery [6, 7]. Research suggests that infants born to mothers who undergo GA during cesarean section may sometimes exhibit lower APGAR scores compared to those born under regional anesthesia. This outcome could be attributed to the direct effects of anesthetic drugs on the newborn, as well as potential respiratory depression [8, 9]. GA agents can cross the placenta, affecting the newborn's respiratory drive. Respiratory depression in the newborn is a critical factor that can contribute to lower APGAR scores [10]. The speed at which the cesarean section is performed under GA may also influence neonatal outcomes. Delayed delivery may impact the APGAR scores due to potential hypoxia and other complications associated with prolonged exposure to anesthesia [10].

Study selection

From 2341 records, 58 studies met the inclusion criteria.

Study characteristics

The included studies varied in design (RCTs, cohort), population size (n=20–1200), and geographic distribution. SA was predominantly used in elective cases, while GA was common in emergencies.

Risk of bias within studies

Moderate to low risk of bias was observed in 80% of studies. High-risk elements included unclear randomization and selective reporting.

Neonatal outcomes

APGAR scores

No significant difference was seen between general and SA. SA exhibited slightly higher scores in elective procedures.

Newborn rectal temperature

There are lower temperatures under SA, though not clinically significant.

Regional cerebral oxygenation

Better outcomes were seen under SA.

Maternal outcomes

Recovery

Faster recovery and greater satisfaction were reported with SA.

Complications

A higher risk of hypotension was seen with SA, though it could be managed effectively.

Clinical implications and considerations

Obstetric anesthesiologists and healthcare providers should carefully weigh the risks and benefits of GA in cesarean sections, considering its potential impact on neonatal well-being. Adequate monitoring and prompt interventions are crucial to mitigate potential adverse effects on APGAR scores [11-13]. Our narrative review draws insights from a network meta-analysis conducted by Kim et al. [14], which systematically compared the maternal and fetal outcomes associated with four distinct anesthetic techniques for cesarean deliveries: General, spinal, epidural, and combined spinal-epidural anesthesia (EA). The meta-analysis revealed significant differences in APGAR scores, particularly favoring SA over GA. The odds of APGAR scores ≤6 at 1 minute were notably lower with SA, indicating potential benefits for immediate neonatal well-being. These findings, supported by moderate-quality evidence, contribute valuable information to our understanding of the comparative impact of anesthesia types on APGAR scores. An interesting observation from the meta-analysis was the association of SA with significantly higher umbilical venous pH than GA. This finding suggests a potential influence of the chosen anesthetic technique on fetal acid-base status, highlighting the importance of considering not only APGAR scores but also physiological parameters. SA emerged as a noteworthy contender, ranking highest for neonatal scores in the meta-analysis. This finding indicates a potential advantage of SA in promoting favorable outcomes for the newborn compared to general, spinal, and combined spinal-EA. Consistent with our focus on APGAR scores, the meta-analysis indicated that SA consistently ranked highest, with impressive surface under the cumulative ranking curve (SUCRA) scores. SA scored the highest for APGAR scoring ≤6 at 1 minute and 5 minutes. SA, on the other hand, received the top ranking for umbilical venous pH and neonatal scores [14].

APGAR scores in repeat cesarean section

Usually, GA has these outcomes and features. First, it is administered intravenously, and its effects are typically rapid. This procedure allows for quick induction and commencement of the cesarean section [15]. Second, medications used for GA can cross the placenta and affect the fetus. While efforts are made to minimize the transfer of these drugs, they can potentially impact the newborn's initial condition. Third, GA can lead to a temporary decrease in uterine blood flow. This reduction in blood flow may affect oxygen delivery to the fetus and can impact the baby's APGAR scores. Fourth, babies born to mothers who received GA may experience a delay in the onset of spontaneous breathing [16, 17]. This delay can affect the respiratory component of the APGAR score.

However, SA has these characteristics. First, it relieves pain by blocking nerve signals in the lower spine. Unlike GA, it does not affect the entire body, and the mother

remains conscious during the procedure. Second, SA typically minimizes maternal blood pressure and uterine blood flow [18-20]. This stability can be advantageous for the well-being of the fetus. Third, SA allows for more controlled and localized administration of medications. This condition can reduce the amount of medication reaching the fetus compared to GA. Fourth, SA often allows immediate skin-to-skin contact between the mother and newborn, promoting bonding and breastfeeding initiation. If we want to compare the effect of these two methods on APGAR scores, we could point out these factors. Infants born to mothers who receive GA may have lower initial APGAR scores due to the factors mentioned, such as potential respiratory depression and decreased uterine blood flow. However, these scores often improve quickly with appropriate medical intervention and monitoring. Babies born under SA are likely to have more stable APGAR scores, as the anesthesia has fewer systemic effects on the mother, and the newborn is less exposed to medications that may impact their condition [21]. Zagorzycki and Brinkman explored the impact of general and SA on neonatal APGAR scores in repeat cesarean sections. A total of 195 elective cesarean deliveries were included, with 90 conducted under GA (0.5% halothane, 50% nitrous oxide, and 50% oxygen) and 105 utilizing the SA (3% chloroprocaine plus 0.75% bupivacaine), with all patients tilted to the left during the operation. The key findings of this study revealed no statistically significant difference in mean APGAR scores at one and five minutes between the two anesthesia groups (P<0.1).

Furthermore, there was no significant difference in the occurrence of depressed infants (APGAR score <7) at one or five minutes, and no correlation was observed between the duration of anesthesia and APGAR scores in either group. Notably, even in cases of prolonged anesthesia duration (≥15 minutes), there was no significant increase in depressed infants. These findings suggest that GA, as described in the study, resulted in neonatal APGAR scores comparable to those delivered under regional block anesthesia. Additionally, the study indicated that prolonged GA duration did not reduce APGAR scores, emphasizing the safety of this anesthesia approach in repeat cesarean sections [22]. Also, in another comprehensive review study by Mattingly et al. [23], the focus is on the effects of obstetric analgesics and anesthetics on neonates. The review emphasizes that while most anesthetic and analgesic agents traverse the placental barrier to varying degrees, judicious administration ensures their tolerability by the fetus. The review discusses various options for labor analgesia, including systemic administration of opioids and sedatives. It notes that repeated maternal administration of opioids such as pethidine (meperidine) can lead to significant fetal exposure and neonatal respiratory depression. Patient-controlled analgesia with synthetic opioids like fentanyl, alfentanil, and remifentanil is presented as an alternative for selected patients. The review highlights spinal and combined spinal-epidural techniques as effective methods for labor analgesia that allow for minimizing or avoiding neonatal exposure to opioids and sedatives. These techniques not only limit fetal exposure to depressant drugs but also improve placental perfusion and oxygenation, which is particularly beneficial in conditions like pregnancy-induced hypertension. The review also underscores that regional blocks are the preferred choice for most cesarean deliveries due to overwhelming evidence of maternal and fetal safety compared to GA. However, it acknowledges that in some instances, GA may be unavoidable. Finally, the review notes neonatal respiratory depression with low APGAR scores and changes in umbilical arterial and venous pH associated with GA are often transient. It emphasizes that an adequately administered regional or general anesthetic has no significant adverse fetal or neonatal effects [23].

Umbilical cord blood gas values

Umbilical cord blood gas values are vital in assessing the newborn's well-being during a cesarean section. This analysis provides valuable insights into the fetal oxygenation and acid-base status, offering a snapshot of the baby's condition at delivery. In a cesarean section, the method and timing of delivery can influence these blood gas values, impacting the infant's APGAR score. Suboptimal values, such as low pH levels or decreased oxygen content, may indicate fetal distress during labor or delivery. Prompt analysis of umbilical cord blood gas values enables healthcare providers to identify potential issues early and initiate appropriate interventions to support the newborn's respiratory and circulatory systems. Addressing deviations from normal umbilical cord blood gas values promptly improves outcomes, ensuring the infant's smooth transition to postnatal life and positively influencing their APGAR score [24-26]. The study by Chen et al. [27] contributes further insights and expands our understanding of the comparative effects of anesthetic techniques in cesarean deliveries. In this double-blind, randomized, controlled study, the impact of GA was compared with combined spinal-EA in 112 parturient women undergoing cesarean section. Building on the assessment of neonatal outcomes, this study evaluated a comprehensive set of parameters,

including umbilical cord blood gas values, postpartum APGAR scores, intraoperative hemodynamics, and various perioperative factors. Consistent with our primary focus, the study found no significant differences between GA and SE groups in APGAR scores, neonatal asphyxia rates, and umbilical arterial and venous cord blood gas values. An interesting observation emerged regarding the time intervals. The GA group exhibited a significantly shorter time interval from anesthesia to delivery, underlining the efficiency of GA in this context. Remarkable differences in adverse reactions were identified. The GA group experienced significantly lower incidences of nausea, vomiting, and chills. Furthermore, postoperative patient satisfaction was notably higher in the GA group compared to the SE group [27]. Similar to this study, Sener et al. provide valuable insights into the comparison between EA and GA on neonatal well-being. The study aimed to evaluate the influence of anesthetic technique on neonatal outcomes in 30 parturient women (ASA I/II), randomly allocated into two groups: Group GA (general anesthesia) and group EA (epidural anesthesia). The findings revealed that 1-minute APGAR scores were significantly higher in the EA group ($P<0.001$), indicating better immediate neonatal well-being. Additionally, neurologic and adaptive capacity (NAC) scores at 2 and 24 hours were higher in the EA group ($P<0.001$), suggesting potential advantages in early neurologic adaptation. Umbilical arterial pH and pO_2 values were higher in the EA group ($P<0.05$ and $P<0.001$, respectively), highlighting favorable acid-base status and oxygenation in neonates under SA. Furthermore, the first breastfeeding intervals were shorter in the EA group ($P<0.001$), indicating a potentially quicker breastfeeding initiation after delivery. In conclusion, the study suggests that SA may be preferred over GA in cesarean sections based on superior APGAR and NAC scores, favorable acid-base status, and earlier breastfeeding initiation [28]. Also, Petropoulos et al. sought to compare the effects of general, spinal, and combined spinal-EA on the short-term outcomes of newborns born to healthy parturients with normal pregnancy. The study included 238 pregnant women undergoing elective cesarean sections after 38 weeks gestation between January 1998 and July 2002. The participants were grouped based on the type of anesthesia administered, and various parameters, including maternal characteristics, birth weight, APGAR scores, and maternal and umbilical artery (UA) acid-base parameters, were analyzed. The results revealed significant differences in maternal pH, pCO_2, and pO_2 among the groups. Specifically, the GA group exhibited lower maternal pH and higher pCO_2 and pO_2 than the other two groups. The pH of the UA was higher in the GA group than in the spinal-epidural group. Moreover, the pO_2 and O_2 saturation of the UA were higher in the GA group compared to the two regional anesthesia modalities. Despite these variations in acid-base status, the study concluded that the type of anesthesia did not influence short-term outcomes in infants born via elective cesarean section. Notably, no fetal acidemia was observed in any group, and neonatal outcomes were similar across the three anesthesia methods. The findings suggest that while differences exist in the acid-base status of both the mother and the newborn, the choice of anesthesia type may not significantly impact short-term outcomes in elective cesarean sections. However, the study highlights the importance of careful use of SA, especially considering the observed differences in acid-base parameters [29].

Newborn rectal temperature

The newborn's rectal temperature during a cesarean section is a key factor in assessing the immediate well-being of the infant. The delivery environment, particularly in the case of cesarean sections, can expose the newborns to variations in temperature that may impact their physiological responses. Maintaining an optimal rectal temperature ensures the baby's thermal stability and comfort. Hypothermia, resulting from inadequate temperature regulation, can adversely affect the infant's respiratory and cardiovascular functions, potentially influencing their APGAR score. Healthcare providers prioritize warmth and swift measures to prevent heat loss in the immediate post-birth period. Strategies such as using radiant warmers, warm blankets, and skin-to-skin contact with the mother contribute to maintaining the newborn's rectal temperature within a healthy range, thus positively impacting their initial APGAR scores and supporting a smooth transition to extrauterine life [30, 31].

Yentur et al. explored the effect of spinal and GA on newborn rectal temperature. This investigation aimed to address the dearth of information regarding the impact of different anesthesia methods on neonatal thermoregulation. A total of 63 pregnant women were randomly assigned to receive either general or SA. Maternal core temperature was measured three times with a rectal probe just before anesthesia, at the beginning of surgery, and delivery. Then, the newborn rectal temperatures were recorded immediately after delivery. Also, APGAR scores were determined at 1, 5, and 10 minutes after birth. Umbilical vein blood was sampled for pH. They found that the SA group had significantly longer anesthesia duration and received a higher volume of intravenous fluid than the GA group ($P<0.0001$).

No significant differences were detected between the spinal and GA groups in maternal rectal temperatures at all measurements. However, newborn rectal temperatures were lower in the SA group immediately after birth compared to the GA group (37.4±0.3 ˚C vs 37.6±0.3 °C; P<0.05). The SA group exhibited lower umbilical vein pH values (7.31±0.05 vs 7.33±0.01; P<0.05) and lower APGAR scores at the 1-minute measurement (8.0±0.9 vs 8.5±0.7; P<0.05) compared to the GA group. They concluded that while maternal core temperatures did not differ significantly between the two groups, newborns delivered under SA exhibited slightly lower rectal temperatures immediately after birth. This observation, coupled with lower umbilical vein pH values and APGAR scores, suggests a mild risk of temperature reduction for babies subjected to SA. It is noteworthy, however, that these reductions did not reach the critical limits of hypothermia [30].

Regional cerebral oxygenation

Regional cerebral oxygenation (rCO) measures oxygen saturation levels in the cerebral tissue, a critical aspect of care during cesarean sections. Monitoring rCO is particularly important in ensuring the well-being of the mother and the newborn. Several factors associated with rCO can significantly influence the APGAR score of the newborn in the context of a cesarean section. Maternal blood pressure and oxygenation directly impact fetal oxygen supply, and low levels of these parameters can decrease oxygen delivery to the fetal brain, potentially affecting the APGAR score [32, 33]. Maternal positioning during the cesarean section also plays a role, as changes in position may influence blood flow and oxygen delivery to the fetus, ultimately affecting rCO. The choice of anesthesia is another crucial factor, with GA potentially impacting blood pressure and oxygen levels differently than regional anesthesia. Anesthesia-related factors can influence the newborn's initial respiratory effort and overall well-being, contributing to the APGAR score [23].

Additionally, the position and presentation of the fetus can affect the ease of delivery during a cesarean section, potentially impacting fetal oxygenation and, subsequently, the APGAR score. Continuous monitoring of rCO provides real-time information about the oxygen status of the fetal brain, allowing healthcare providers to make timely interventions if oxygen levels are suboptimal. Ensuring timely cesarean section and maintaining maternal hemodynamic stability through appropriate fluid management and blood pressure support are essential to optimizing fetal well-being during this critical period [3, 10, 18, 34]. Ozgen et al. evaluated potential differences in regional cerebral oxygen saturation ($RcSO_2$) of newborns born under GA versus combined spinal-EA (CSEA) during elective cesarean deliveries. A total of 68 patients were included in the study, 32 undergoing GA (group I) and 36 receiving combined spinal-EA (group II). The mother's age, gestation, pregnancy-related issues, maternal heart rate, blood pressure, and oxygen saturation (SpO_2) were recorded. Newborn measurements included SpO_2 of the right hand, $RcSO_2$ measured by near-infrared spectroscopy (NIRS), delivery time, and APGAR scores. Results showed no significant differences between the groups regarding maternal age, gestation week, and baseline blood pressure. However, mothers who underwent combined spinal-EA had significantly lower systolic and diastolic blood pressures at 1 and 5 minutes after induction or the start of the spinal block. Additionally, the heart rates of mothers in the CSEA group were significantly higher than those in the GA group. Regarding newborn outcomes, APGAR scores at the first minute were significantly higher in Group II, and the oxygen saturation of the newborns was significantly higher in the same group. Importantly, regional cerebral oxygenation measured by NIRS was also significantly higher in the CSEA group. In conclusion, the study suggests that combined spinal-EA and its known advantages demonstrated superiority over GA regarding regional cerebral oxygenation for newborns. These findings contribute to the ongoing discussion regarding the choice of anesthesia method in cesarean deliveries, emphasizing potential benefits for neonatal well-being [35].

Placenta previa totalis (PPT)

PPTis a condition in which the placenta completely covers the cervix, blocking the baby's exit from the uterus. This condition poses significant challenges during delivery and can have implications for the APGAR score of the newborn [36]. First, PPTcan increase the risk of fetal distress during labor and delivery. The placenta may be more prone to bleeding, and the baby may not receive an adequate supply of oxygen and nutrients, potentially affecting the APGAR score [37-39]. Second, due to the risks associated with placenta previa totalis, there might be a decision to deliver the baby prematurely via cesarean section before the onset of labor. Premature birth can impact the baby's APGAR score, as premature infants may face challenges related to lung maturity and other developmental factors [40, 41]. Third, PPT is associated with an increased risk of bleeding during delivery. Excessive bleeding can decrease the oxygen supply to the baby, affecting the APGAR score, particularly in

the area of color [42]. Fourth, in some cases, emergency procedures such as blood transfusions or a rapid delivery via cesarean section may be required to address complications arising from placenta previa totalis. The urgency of these interventions can influence the newborn's initial condition and APGAR scores [43]. Fifth, pregnant individuals with PPT are closely monitored during pregnancy through regular ultrasound examinations and other assessments. This monitoring aims to detect any signs of complications and inform decisions regarding the timing and mode of delivery [44, 45]. Sixth, in many cases of placenta previa totalis, a planned cesarean section is scheduled before the onset of labor to minimize the risks associated with vaginal delivery. This planned approach allows for careful coordination of medical resources and preparedness for potential complications [37]. Finally, given the potential challenges associated with placenta previa totalis, infants born in such situations may require special attention and care in the neonatal intensive care unit (NICU). Monitoring and support in the NICU can help address any issues that may impact the APGAR score [46]. In a prospective randomized trial comparing anesthesia methods for cesarean section in patients diagnosed with grade 4 placenta previa, Hong et al. assessed the impact on maternal hemodynamics, blood loss, and neonatal outcomes between general and SA. Twelve patients received GA, while 13 received SA. The study revealed that intraoperative blood pressures demonstrated a more stable course in the spinal group than the GA group. Despite no significant difference in blood loss between the groups (1622±775 mL vs 1418±996 mL), GA resulted in a lower immediate postoperative hematocrit level (28.1±3.5% vs 32.5±5.0%, P<0.05). Furthermore, patients in the GA group received a significantly larger transfusion than the SA group (1.08±1.6 vs 0.38±0.9 units, P<0.05). However, APGAR scores at 1 and 5 minutes were similar in both groups (8 [4-9] vs 8 [7-9] and 10 [6-10] vs 9 [9-10], respectively).The study concluded that SA was superior to GA in elective cesarean sections for grade 4 placenta previa, particularly regarding maternal hemodynamics and blood loss. Importantly, no difference in neonatal outcomes was observed between the two anesthesia methods. These findings contribute valuable insights into the considerations for anesthesia choice in cases of placenta previa, emphasizing the potential benefits of SA for maternal outcomes without compromising neonatal well-being [36]. In another study, Fan et al. focused on assessing the maternal and neonatal outcomes of patients with placenta previa undergoing cesarean delivery with either neuraxial or GA. The study included 1234 patients, 737 receiving neuraxial anesthesia and 497 undergoing GA. The key conclusion drawn from this study is that neuraxial anesthesia is associated with significantly better outcomes compared to GA in the context of cesarean delivery for placenta previa. Notably, the mean estimated blood loss was markedly lower with neuraxial anesthesia, demonstrating a potential advantage in minimizing maternal hemorrhage during the procedure. The reduced need for blood transfusions in the neuraxial group further emphasizes the favorable maternal outcomes associated with this anesthesia approach. In terms of neonatal outcomes, the study found a lower rate of neonatal asphyxia and NICU admission in the neuraxial anesthesia group. This finding is critical, indicating a potential protective effect of neuraxial anesthesia on neonatal well-being in the context of placenta previa cesarean deliveries. The findings from this study contribute valuable insights for our comprehensive study on the assessment of anesthesia types in cesarean sections and their impact on APGAR scores, maternal hemodynamics, and neonatal outcomes. The data suggest that choosing neuraxial anesthesia over GA might be beneficial, potentially reducing blood loss, lowering the need for transfusions, and improving neonatal outcomes [47].

Discussion

The anesthesia method, particularly in cesarean sections, is crucial in determining neonatal outcomes, as reflected by APGAR scores. In this discussion, we explored the comparative effects of GA and SA on APGAR scores and various neonatal parameters, drawing insights from multiple studies.

GA vs SA: Impact on APGAR scores

APGAR scores in repeat cesarean sections

Zagorzycki and Brinkman investigated the impact of general and SA on neonatal APGAR scores in repeat cesarean sections [22]. The findings revealed no statistically significant difference in mean APGAR scores between the anesthesia groups at one and five minutes. Importantly, even in cases of prolonged anesthesia duration, there was no significant increase in depressed infants. This finding suggests that, in this specific context, GA resulted in neonatal APGAR scores comparable to those delivered under SA [22].

Comprehensive review study on obstetric analgesics and anesthetics

Mattingly et al's comprehensive review emphasized the safety of general and regional anesthesia methods, highlighting that a properly administered anesthetic, whether regional or general, has no significant adverse fetal or neonatal effects [23]. This finding supports the notion that the choice between general and SA should consider individual patient factors and clinical circumstances.

Comparative studies on APGAR scores and neonatal outcomes

Chen et al.'s study comparing GA with combined spinal and EA found no significant differences in APGAR scores and neonatal asphyxia rates. Notably, the efficiency of GA in achieving a shorter time interval from anesthesia to delivery was observed, highlighting a potential advantage in some instances [27].

Similarly, Sener et al. compared SA with GA and found that 1-minute APGAR scores were significantly higher in the SA. This study also indicated favorable acid-base status, oxygenation, and earlier breastfeeding initiation in neonates under SA [28].

Short-term outcomes in elective cesarean sections

Petropoulos et al.'s study compared general, spinal, and combined spinal-EA in elective cesarean sections. While differences existed in maternal and neonatal acid-base status, the type of anesthesia did not significantly impact short-term outcomes, emphasizing the importance of careful anesthesia use [29].

Additional considerations: Newborn rectal temperature and regional cerebral oxygenation

Newborn rectal temperature

Yentur et al.'s investigation of the spinal and GA on newborn rectal temperature revealed that newborns delivered under SA exhibited slightly lower rectal temperatures immediately after birth. While within acceptable limits, this observation and lower APGAR scores suggest a mild risk of temperature reduction for babies subjected to SA [30].

Regional cerebral oxygenation

Ozgen et al.'s study comparing regional cerebral oxygenation ($RcSO_2$) in newborns born under GA versus combined spinal-EA during elective cesarean deliveries found significantly higher $RcSO_2$ in the combined spinal-EA group. This finding highlights potential advantages regarding regional cerebral oxygenation for newborns under this anesthesia method [35].

Special considerations: Placenta previa totalis

Effects on APGAR scores and maternal outcomes

Studies focusing on placenta previa totalis, such as those by Hong et al. [36] and Fan et al. [47], underscored the importance of anesthesia choice in managing this challenging condition. Hong et al. [36] found that SA was superior to GA, particularly regarding maternal hemodynamics and blood loss, with no observed difference in neonatal outcomes. Similarly, Fan et al.'s study demonstrates that neuraxial anesthesia was associated with significantly better outcomes than GA in cesarean deliveries for placenta previa [47]. These outcomes included lower estimated blood loss and reduced rates of neonatal asphyxia and NICU admission.

Key considerations and implications for clinical practice

In summary, the collective findings suggest that general and SA can be safe and effective in cesarean sections, with specific nuances depending on the clinical context. The choice of anesthesia should consider factors such as the urgency of the procedure, maternal health, and potential impact on neonatal outcomes. SA may offer advantages in certain scenarios, such as improved neonatal well-being and regional cerebral oxygenation. However, it is crucial to note that individual patient characteristics and clinical circumstances play a significant role in determining the most appropriate anesthesia method. Careful monitoring, timely interventions, and a multidisciplinary approach are essential for optimizing both maternal and neonatal outcomes in cesarean sections, especially in high-risk conditions like PPT. As obstetric anesthesia evolves, ongoing research and evidence-based practices will further refine our understanding of the nuanced effects of different anesthesia methods, ultimately contributing to improved outcomes for mothers and newborns in cesarean deliveries.

Conclusion

In conclusion, while both general and spinal anesthesia are acceptable for cesarean sections, our review indicates spinal anesthesia may offer advantages, particularly for neonatal outcomes. The optimal choice

requires careful consideration of the patient's clinical needs, delivery urgency, and potential benefits. Further research should focus on validating these findings and refining anesthesia protocols to optimize outcomes for mothers and newborns.

Summary of evidence

Both anesthesia methods ensure neonatal safety, with SA demonstrating neonatal advantages in elective cesareans. GA remains crucial for emergencies, balancing risks with rapid induction.

Study limitations

Variability in study quality, limited RCTs, and heterogeneous populations restrict definitive conclusions.

Future directions

Large-scale RCTs exploring long-term neonatal and maternal outcomes are warranted.

Ethical Considerations

Compliance with ethical guidelines

This review followed PRISMA (preferred reporting items for systematic reviews and meta-analyses) guidelines and was registered in the International Prospective Register of Systematic Reviews (PROSPERO) (Code: CRD42023064528).

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Authors contributions

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Conflicts of interest

The authors declared no conflict of interest.

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