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Original article

Effect of Maternal Oxygenation with Spinal Anesthesia on Neonatal Outcome in Full Term Elective Cesarean Section

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Abstract

Background: Understanding the implications of maternal oxygenation during elective cesarean sections with spinal anesthesia on neonatal outcomes is crucial for optimizing perinatal care. This study aimed to determine the effect of maternal oxygenation on neonatal outcome in full term elective cesarean section under spinal anesthesia. **Methods:** This randomized controlled trial, conducted from June to December 2022 at Benha University Hospital, included pregnant patients beyond 37 weeks of gestation undergoing elective cesarean section. Participants were divided into two groups: Group A received oxygen supplementation, while Group B did not. Various assessments, including maternal and neonatal parameters, were conducted. **Results**: Group A exhibited significantly higher maternal oxygen levels (100 ± 0 vs. 95 ± 1, P < 0.001). Neonates in Group A demonstrated lower umbilical vein carbon dioxide (35.3 ± 6.4 vs. 39.4 ± 7.8, P = 0.013) and bicarbonate levels (19.3 ± 2.7 vs. 21.6 ± 5.3, P = 0.019) but higher oxygen levels (34 ± 6 vs. 22 ± 4, P < 0.001). Apgar scores were higher in Group A at 1 minute (median = 9 vs. 8, P = 0.023), 10 minutes (median = 10 vs. 9, P < 0.001), and 20 minutes. Group A neonates also had significantly higher oxygen levels at 1, 3, 5, and 10 minutes post-delivery but there was no statistically significant difference in admission rate. **Conclusion:** Maternal oxygenation during elective cesarean sections may positively influences neonatal outcomes, as evidenced by improved Apgar scores and higher neonatal oxygen levels but no effect on admission rate.

Keywords: Maternal Oxygenation; Neonatal Outcome; Elective Cesarean Section; Spinal Anesthesia; Apgar Score.

Introduction

Global caesarean section (CS) rates have risen steadily over 25 years, with 1.4 million CS births annually in the European Union. CS, whether planned or emergency, is recommended for maternal factors (age≥40, obesity, etc.) and fetal reasons (twins, breech position, etc.). The procedure impacts intrauterine pressure, affecting fetal oxygenation, blood pressure, and heart rate. Prolonged fetal hypoxia increases risks of morbidity and fetal death (1).

Neonatal resuscitation with 100% oxygen may lead to an increase in neonatal mortality and morbidity. However, maternal hyperoxygenation has a positive effect on the fetal heart rate in the presence of suspected fetal distress during the second stage of labor, without any severe maternal side effects (2).

Maternal oxygen supplementation is a widely used intrauterine resuscitation technique recommended by the American College of Obstetricians and Gynecologists for the management of abnormal fetal heart rate tracings (3).

Maternal supplemental O2 clearly may be a benefit for mothers with hypoxemia. Supplemental O2 may be of most benefit for late decelerations associated with fetal hypoxemia, whereas it is unlikely to significantly benefit variable decelerations because of umbilical cord occlusion. Maternal hyperoxia with normocapnia was associated with increased umbilical artery pulsatility, suggesting placental vasoconstriction. However, maternal hyperoxia without maintenance of normocapnia did not cause such an increase (4).Peripartum

maternal oxygen supplementation is not associated with a clinically relevant improvement in the Umbilical vein (UV) pH or other neonatal outcomes (5).

The Apgar score is a swift assessment method for newborns immediately after birth and during resuscitation. Endorsed by the American College of Obstetricians and Gynecologists (ACOG) and the American Academy of Pediatrics (AAP), it evaluates color, heart rate, reflexes, muscle tone, and respiration, assigning scores of 0, 1, or 2 to each element. Apgar scores are recorded at 1- and 5-minutes post-birth. If the score is below 7, both ACOG and AAP recommend expanded Apgar score recording for monitoring the response to resuscitation (6). So, the effect of maternal oxygenation on neonatal outcomes needs further studies, and this study is to detect if mother hyperoxygenation during spinal anesthesia affects neonatal outcomes in full-term elective c-section babies in relation to resuscitation and observation during the first 15-20 minutes. The purpose of this study was to determine the effect of maternal oxygenation on neonatal outcome in full term elective cesarean section under spinal anesthesia.

Patients and methods

Patients:

This randomized controlled trial was conducted in the Obstetrics and Gynecology Department and Neonatology Department of Benha University Hospital during the period from June 2022 to December 2022. The study focused on pregnant patients at 37 weeks' gestation or beyond, specifically those undergoing elective Caesarean section with spinal anesthesia.

Ethical considerations:

Informed consents were obtained from all the parents. The study was approved by the ethics committee on research involving human subjects of Benha faculty of Medicine (Approval Code: MS.12.7.2022). An administrative permission was taken.

Inclusion criteria were patients meeting specific conditions: maternal age between 20 and 40 years, a single full-term fetus at or beyond 37 weeks, and the intention for an elective Caesarean section with spinal anesthesia.

Exclusion criteria applied to those with certain conditions, such as major fetal anomalies, multiple gestations, suspected infection during labor, preterm babies, intrauterine growth restriction (IUGR), congenital malformations, and prolonged bradycardia in infants. Maternal exclusion criteria involved diseases like cardiac or pulmonary diseases, diabetes, hyperthyroidism, or anemia (hemoglobin < 6.5 mmol/L or 10.5 g/dl), emergency Caesarean sections (e.g., antepartum hemorrhage), and maternal hypoxia.

The participants were then divided into two groups: Group A, consisting of 40 babies of pregnant women supplied with oxygen 10 minutes before and during the operation, and **Group B**, comprising 40 babies of pregnant women without oxygen supply (room air).

Methods

Patient Assessment:

Each patient underwent a thorough assessment encompassing a detailed history and comprehensive general examination. Maternal information, medical and obstetric history, family history, and perinatal details were meticulously recorded. The general examination covered various aspects such as the neonate's appearance, vital signs, skin condition, head and face morphology, chest and breathing patterns, abdominal palpation, assessment of extremities, neurological reflexes, genitalia inspection, and weight and measurements.

Preoperative Procedures:

The preoperative phase involved strategic steps to ensure patient readiness for surgery. Patients received ranitidine

for gastric acidity reduction and aspiration prevention. The surgical team prepared the anesthesia machine, airway equipment, and resuscitation drugs. Continuous monitoring during the procedure included electrocardiography (ECG), oxygen saturation (SpO2), noninvasive blood pressure, and respiratory rate assessments. Nasal maternal oxygenation at a rate of 3 L/min via a nasal cannula was applied for 10 minutes before operation, and during the operation.

Intravenous Line and Fluid Administration:

Before administering anesthesia, an 18G IV cannula was established for medication and fluid administration. Ringer's lactate solution, an isotonic fluid, was used to maintain hydration and electrolyte balance during surgery.

Monitoring During Anesthesia:

Continuous monitoring parameters during anesthesia included noninvasive arterial pressure, ECG, and pulse oximetry to ensure the patient's cardiovascular and respiratory stability.

Administration of Spinal Anesthesia:

Spinal anesthesia involved a nasal cannula for oxygen supplementation, and participants were randomized to receive either oxygen or air. A 26G Quincke spinal needle was used for aseptic insertion into the L3-L4 intervertebral space, and 10 mg of 0.5% hyperbaric bupivacaine was administered.

Management of Hypotension and Bradycardia:

Surgeons proceeded with the procedure once the sensory block reached a specified level. Blood pressure was monitored regularly, and hypotension was managed with phenylephrine and fluid administration. Bradycardia was addressed with atropine, ensuring the patient's cardiovascular stability throughout the surgery.

Assessment of Newborn's Condition:

A pediatrician, unaware of the group allocation, attended each delivery to assess the newborn's condition. The fetal general examination included careful observation of the baby's skin color, with scores assigned based on overall coloration to indicate oxygenation status. Heart rate assessment allocated points for detectable heartbeat, heart rate range, and reflex irritability or grimace response. Muscle tone evaluation considered the baby's limb activity and overall muscle tone. Breathing effort assessment observed respiratory patterns for insights into breathing and oxygen intake.

Expanded APGAR Score:

The expanded APGAR score, evaluated up to 20 minutes after delivery, included assessments of color, heart rate, reflex irritability, muscle tone, and respiration. Scores were recorded at 1, 5, 10, 15, and 20 minutes, providing a comprehensive

evaluation of the newborn's condition over time.

Neonatal SpO_2 Assessment:

Neonatal SpO2 was measured using a pulse oximeter at 1, 3, 5, and 10 minutes after delivery. Desaturation, defined as SpO2 below 94% for more than 30 seconds, was monitored, ensuring good signal quality and probe stability to confirm desaturation events.

Umbilical venous Blood Gas (UVBG) Assessment:

The umbilical cord was clamped and cut after the baby's birth. A small section of the umbilical vein was punctured using a needle, and a blood sample was collected for ABG analysis. The blood sample was sent to the laboratory for immediate analysis. Parameters such as pH, partial pressure of oxygen (PaO2), partial pressure of carbon dioxide (PaCO2), base excess (BE), and lactate levels were measured.

Statistical analysis

Data management and statistical analysis were conducted using SPSS version 28 (IBM, Armonk, New York, United States). Initial assessment of quantitative data for normality was performed using the Shapiro-Wilk test and direct data visualization methods. Based on normality, quantitative data were presented as means and standard deviations or medians and ranges. Categorical data were summarized as numbers and percentages. Statistical comparisons between groups utilized the independent t-test or Mann-Whitney U test for normally and non-normally distributed quantitative variables, respectively. Categorical data comparisons employed the Chi-square or Fisher's exact test. Correlations were assessed using Pearson's or Spearman's correlation. Multivariate linear regression analyses were employed to predict PO2 at different times, with calculated regression coefficients and 95% confidence intervals. All statistical tests were two-sided, and significance was established at p-values less 0.05 with a 95% confidence interval.

Results

Demographic data and prenatal characteristics:

No significant differences were observed between the studied groups regarding age (P = 0.325) and consanguinity (P = 0.762). Gestational age significantly differed between the studied patients (P = 0.023), with the 39th and 38th-week gestational ages representing 50% for each in group B, while in group A, the 37th, 38th, and 39th-week gestational ages represented 15%, 52.5%, and 32.5%, respectively. Additionally, maternal O2 was significantly higher in group A (100 ±0 vs. 95 ±1, P < 0.001). No significant difference was observed between the studied groups regarding birth weight (P = 0.496). **Table 1**

UVBG

Neonates in group A exhibited significantly lower UV CO_2 (35.3 ±6.4

vs. 39.4 ±7.8, P = 0.013) and HCO_3 (19.3 ±2.7 vs. 21.6 ±5.3, P = 0.019) compared to group B. In contrast, group A demonstrated significantly higher PO_2 (34 ±6 vs. 22 ±4, P < 0.001). No significant difference was observed regarding PH (P = 0.923). **Figure 1**

APGAR score:

Higher medians or ranges of APGAR scores were significantly observed in group A than in group B at 1 minute (median = 9 vs. 8, P = 0.023), 5 minutes (median = 9 for each, range = 8-10 in group A vs. 8-9 in group B), 10 minutes (median = 10 vs. 9, P < 0.001), and 20 minutes (median = 10 for each, range = 8 – 10 in group B compared to 10 for all patients in group A). **Table 2**

Outcomes:

Group A demonstrated significantly higher SPO_2 at 1 minute (71 ±3 vs. 63 ±2, P < 0.001), 3 minutes (85 ±3 vs. 74 ±2, P < 0.001), 5 minutes (91 ±1 vs. 84 ±2, P < 0.001), and 10 minutes (96 ±1 vs. 95 ±1, P = 0.006). No significant difference was observed regarding NICU admission (P = 1.0). **Table 3**

Correlation between SPO2 at 1 minute, 3 minutes, 5 minutes and 10 minutes and other parameters in group A

In group A, SPO_2 at 1 minute showed a significant positive correlation with birth weight (r = 0.519, P = 0.001). No significant correlations were observed with other parameters. **Figure 2 A)**

In group A, SPO_2 at 3 minutes showed a significant positive correlation with UV PO_2 (r = 0.478, P = 0.002). In contrast, it showed significant negative correlations with heart rate (r = -0.350, P = 0.027) and respiratory rate (r = - 0.350, P = 0.027). No significant correlations were observed with other parameters. **Figure 2B, C and D)**

In group A, SPO_2 at 5 minutes showed a significant positive correlation with umbilical vein PO_2 (r = 0.413, P = 0.008). No significant correlations were observed with other parameters. **Figure 2 E)**

In group A, SPO_2 at 10 minutes showed a significant positive correlation with umbilical vein PO2 (r = 0.426, P = 0.006). No significant correlations were observed with other parameters. **Figure 2 F)**

Multivariate linear regression analyses were done to predict neonatal SPO_2 at different time points using oxygen supply as a predictor and controlling for age, gestational age, consanguinity, and birth weight. Oxygen supply was significantly associated with increased SPO_2 by 8.381 at one minute (B = 8.381, 95% CI = 7.326 – 9.436, P < 0.001), 12.043 at three minutes (B = 12.943, 95% CI = 10.972 – 13.113, p < 0.001), 6.728 at five minutes (OR = 6.728, 95% CI = 6.089 – 7.367, P < 0.001), and 0.887 at ten minutes (B = 0.887, 95% CI = 0.292 – 1.481, P = 0.004). **Table 3**

Table 1: Demographic data and prenatal characteristics of the studied groups

		Group A (n = 40)	Group B (n = 40)	P-value
Age (years)	Mean ±SD	30 ±5	29 ±6	0.325
Consanguinity	n (%)	6 (15.0)	7 (17.5)	0.762
Gestational age (weeks)				
37th week	n (%)	6 (15.0)	0 (0.0)	**0.023***
38th week	n (%)	21 (52.5)	20 (50.0)	
39th week	n (%)	13 (32.5)	20 (50.0)	
Birth weight (kg)	Mean ±SD	3.15 ±0.218	3.114 ±0.25	0.496
Maternal risk factors	n (%)	0 (0.0)	0 (0.0)	-
Maternal O_2	Mean ±SD	100 ±0	95 ±1	**<0.001***

*Significant P-value.

Table 2: APGAR score at different times in the studied groups

APGAR		Group A (n = 40)	Group B (n = 40)	P-value
1 minute	Median (range)	9 (8 - 9)	8 (8 - 9)	**0.023***
5 minutes	Median (range)	9 (8 - 10)	9 (8 - 9)	**<0.001***
10 minutes	Median (range)	10 (9 - 10)	9 (8 - 10)	**<0.001***
20 minutes	Median (range)	10 (10 - 10)	10 (8 - 10)	**0.041***

*Significant P-value.

Table 3: Outcome parameters in the studied groups

		Group A (n = 40)	Group B (n = 40)	P-value
NICU admission	n (%)	2 (5.0)	3 (7.5)	1.0
		SPO_2		
1 minute	Mean ±SD	71 ±3	63 ±2	**<0.001***
3 minutes	Mean ±SD	85 ±3	74 ±2	**<0.001***
5 minutes	Mean ±SD	91 ±1	84 ±2	**<0.001***
10 minutes	Mean ±SD	96 ±1	95 ±1	**0.006***

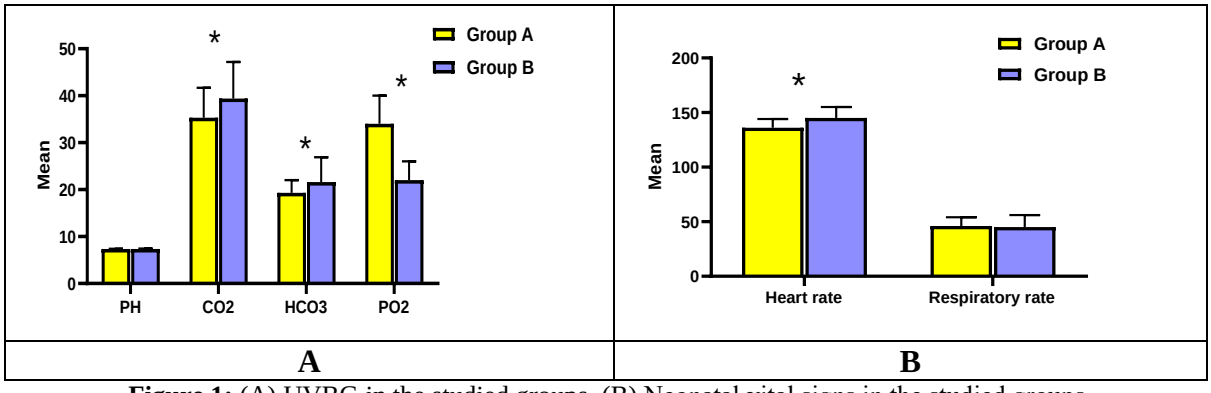

Figure 1: (A) UVBG in the studied groups, (B) Neonatal vital signs in the studied groups

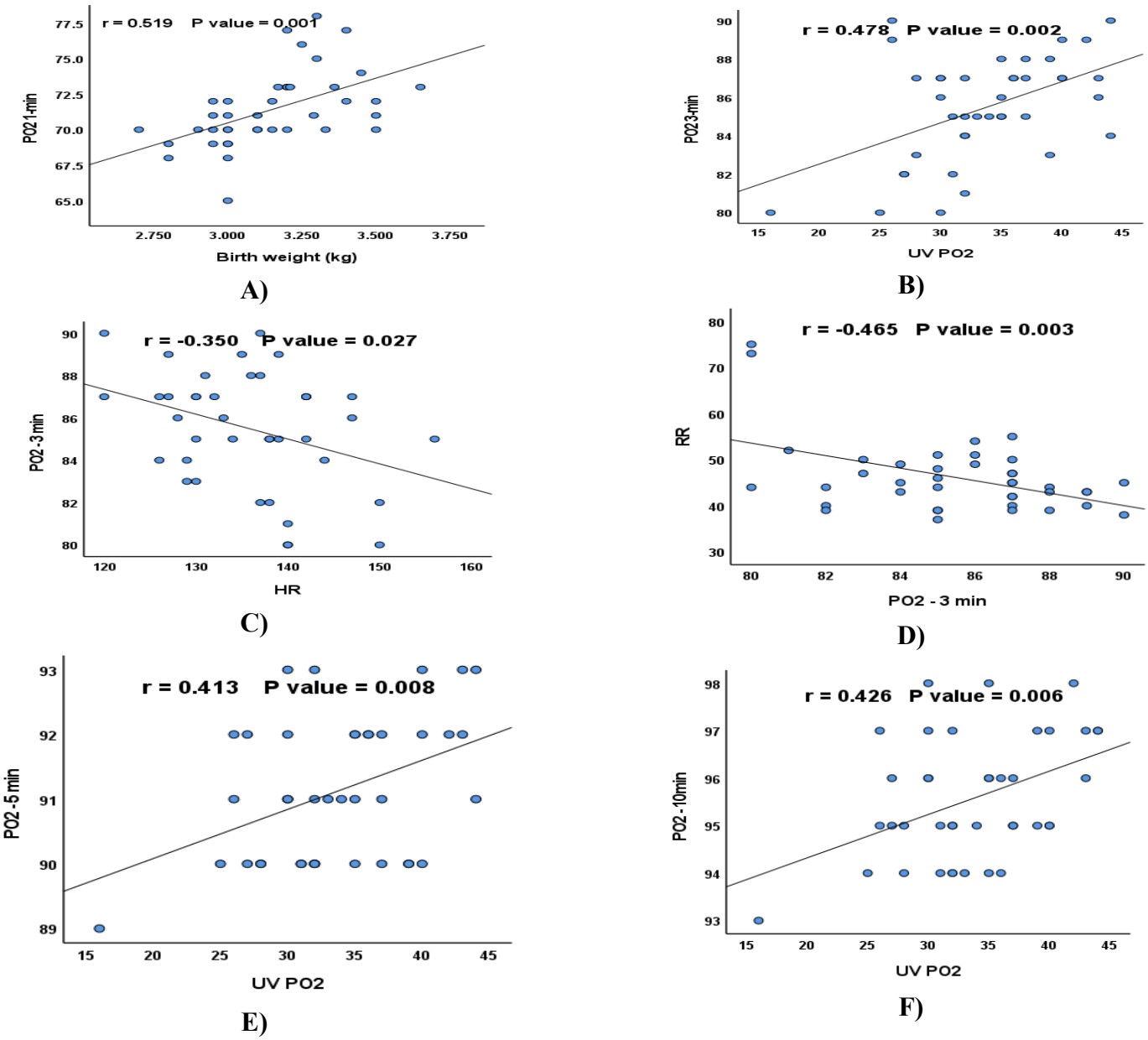

Figure 2: A) Correlation between SPO2 at 1 minute and birth weight in group A, B) Correlation between SPO_2 at 3 minutes and UV PO_2 in group A, C) Correlation between SPO_2 at 3 minutes and heart rate in group A, D) Correlation between PO_2 at 3 minutes and respiratory rate in group A, E) Correlation between PO_2 at 5 minutes and UV SPO_2 in group A and F) Correlation between SPO_2 at 10 minutes and UV PO_2 in group A

Discussion

Administering supplemental oxygen during cesarean section (CS) under spinal anesthesia is a longstanding practice to counteract the potential hypoxia resulting from spinal anesthesia-induced hypotension. The conventional monitoring methods exhibit a time lag in detecting and addressing hypotension, exposing patients to a period of hypoxia (7). Preventive measures for hypotension include volume expansion, vasopressors, appropriate positioning, and supplemental

oxygen. However, while supplemental oxygen may enhance oxygen delivery and benefit the fetus, it doesn't entirely prevent the issue (8). Prolonged CS, associated with increased uterine incision to delivery time, may lead to fetal acidosis, and administering oxygen during this critical time is contentious due to potential side effects like maternal hyperoxia and increased oxygen-free radical activity (9).

This randomized controlled study aims to contribute to guideline development by assessing the efficacy of routine supplemental oxygen administration in improving neonatal outcomes during elective CS under spinal anesthesia.

The study, conducted at Banha University Hospital and Banha Teaching Hospital from June to December 2022, involved forty pregnant females in each of two groups. Group A received supplemental oxygen 10 minutes before and throughout elective CS, while Group B, the control, relied on room air during CS.

No significant age or consanguinity differences were observed between groups, but gestational age showed significant variation, with Group A having a diverse distribution across 37th, 38th, and 39th weeks. Maternal oxygen levels were significantly higher in Group A (100 ±0) than in Group B (95 ±1), aligning with previous studies. Birth weight showed no significant distinction between groups, consistent with findings by (10). UVBG analysis revealed significant differences in CO2, HCO3, and PO2 levels between neonates in Group A and Group B, emphasizing the impact of supplemental oxygen on fetal outcomes.

In studies in India (10), it was found that in the oxygen group compared to the air group, fetal acidosis (FA) proportion was significantly lower, and UA PCO2 and UV PCO2 were also significantly lower in the oxygen group. However, UA or UV PO2 showed no significant difference. UA bicarbonate levels were higher in the air group compared to the oxygen group. APGAR scores did not exhibit statistically significant differences.

Moreover, several studies (11-13) provided varying results regarding UVBG and UV oxygenation, demonstrating the complexity and nuances of the impact of oxygen administration on neonatal parameters.

Regarding APGAR scores, studies (5-10-12) showed that infants of mothers receiving oxygen during scheduled Cesarean delivery had slightly lower 1-minute Apgar scores than those whose mothers were receiving room air.

In terms of neonatal vital signs and outcomes, several studies (2, 14, 15) concurred that there was no significant difference in the rate of NICU admission between the oxygen and room air groups. Similarly, research (16) indicated that supplementary oxygen during elective caesarean section elevated maternal and neonatal oxygen levels, including

maternal SpO2, PaO2, UaPO2, and UvPO2, without significant short-term clinical outcome impact on the neonate.

Moreover, a study (17) suggested that supplementing oxygen to the mother during the procedure is unnecessary and does not lead to better outcomes for the fetus. In the realm of spinal anesthesia complications among mothers, Group A demonstrated a significantly lower incidence of hypotension (47.5% vs. 72.5%, P = 0.022) and headache (47.5% vs. 72.5%, P = 0.022) compared to Group B. This suggests that oxygen supplementation before and during the elective Cesarean section played a role in reducing the occurrence of these complications. However, no significant difference was noted in terms of nausea and vomiting (P = 0.499) between the two groups.

Supporting these findings, a study (7) reported a lower incidence of intraoperative hypotension in the group receiving supplemental oxygen. These outcomes underscore the potential benefits of administering oxygen in mitigating certain adverse effects associated with spinal anesthesia during elective Cesarean sections, promoting a safer and more comfortable experience for the mothers involved.

In the study's exploration of neonatal oxygen saturation (SPO2) at different post-birth intervals, significant positive correlations were found between SPO2 and birth weight at 1-minute post-birth, umbilical PO2 levels at 3 and 5 minutes, and sustained correlation with PO2 levels at 10 minutes. Multivariate linear regression analyses demonstrated the substantial impact of oxygen administration on increasing SPO2 levels at 1-, 3-, 5-, and 10-minutes post-birth, highlighting its consistent positive influence on neonatal oxygen saturation. However, the study concludes that existing evidence does not support maternal oxygen administration for cases of non-reassuring fetal heart rate patterns, citing conflicting results in recent decades and potential adverse effects on both the newborn and mother. Instead, the focus is advised to shift towards discouraging routine maternal oxygen administration in normoxic patients during labor, advocating for alternative intrauterine resuscitation techniques in cases of fetal distress, and reserving oxygen for instances of maternal hypoxia to ensure normal oxygen saturation.

Conclusion

Maternal oxygenation during elective cesarean sections under spinal anesthesia may improves neonatal outcomes, as evidenced by higher SpO2 levels, favorable umbilical vein blood gas parameters, and superior APGAR scores. However, there was no distinction between the two groups' UVBG PH or admission rate. There is debate over peripartum mother oxygenation without fetal distress or maternal hypoxia.

Limitations

This was a single center study with a relatively small sample size of 80 infants which may limit the generalizability of our findings to a broader population.

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