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Effect of Mode of Anesthesia on Fetal Acid-Base Status at Cesarean Section

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ABSTRACT

Background: It is well-known that there's more risk of neonatal respiratory distress with babies born by cesarean delivery than vaginal delivery, regardless of fetal gestational age.

Objectives: The aim of this work was to evaluate if different modes of anesthesia affect fetal acid-base for cesarean sections.

Patients and methods: This cross-sectional study was conducted on newborns of 150 pregnant women of full-term babies aged 20 to 35 years with no previous maternal medical condition, undergoing elective caesarean section. Patients were allocated into two equal groups; SA group where cesarean sections were done under spinal anesthesia and GA group where cesarean sections were done under general anesthesia. All neonates underwent history taking, and postnatal history including general neonatal examination, Apgar score, neurological examination [Mental status, sensory perception, and reflexes] and systemic examination. Cord blood samples were taken from participant newborns, and immediately after birth and the taken samples were sent for blood gas analysis.

Results: There was a significant strong positive correlation between the outcomes and PH, PO_2, and PCO_2. Regarding univariate correlations and multivariate correlations, there was a significant strong positive correlation between the outcomes and PH, PO_2 and PCO_2 (P value= <0.0001).

Conclusions: It could be concluded that umbilical cord arterial blood gas values, Apgar score (at 1, 5 and 10 min after birth) and neonatal asphyxia are comparable between the two different modes of anesthesia (spinal and general). Moreover, there are significant strong positive correlations between the outcomes and PH, PO_2, and PCO_2, and they also are strong predictors of the neonatal outcome.

Keywords: Mode of Anesthesia, Fetal Acid-Base Status, Cesarean Section, Gestational Age, Neonatal.

INTRODUCTION

A caesarean section is usually described as elective (when it's planned) or emergency (when there is risk on either mother or fetus or both). It's well-known that there's more risk of neonatal respiratory distress with babies born by cesarean delivery than vaginal delivery, regardless of fetal gestational age [1].

Both general and spinal anesthesia are frequently utilized during cesarean sections, and each has its own set of benefits and drawbacks [2].

Spinal anesthesia is the preferred method for cesarean delivery not only because it circumvents the potential hazards associated with general anesthesia, such as failed intubation and its repercussions, but also because it offers more efficient pain management, early ambulation, and thus facilitates the resumption of daily activities for postpartum women [3].

Each method of anesthesia has benefits and drawbacks. Rapid induction, reduced hypotension, improved respiratory tract and ventilation control, and preserved cardiovascular balance are all advantages of GA. Conversely, aspiration of stomach contents, intubation difficulties, and respiratory depression in the neonate are all disadvantages. Regional anesthesia significant benefits include the mother remaining conscious during the delivery process, observing the newborn at birth, facilitating early breastfeeding, and preventing respiratory depression in the neonate. Drawbacks include the potential for nausea and vomiting, headache in the mother due to cerebrospinal fluid (CSF) leakage following lumbar puncture, and a restricted effect duration. In addition, fetal acidemia is caused by hypotension resulting from the reduction in uteroplacental perfusion and intervillous blood flow caused by the sympathetic blockage induced by RA. Apgar scoring is frequently employed as a rapid method of evaluating the clinical condition of neonates. It is generally accepted that umbilical cord blood gas values are a more dependable indicator of fetal oxygenation and neonatal clinical status [4].

There are much research investigating the relation between mode of anesthesia and fetal outcome regarding either Apgar score of the newborn or fetal acid-base balance. Some have noted no difference in Apgar score between spinal or general anesthesia groups. Some have shown that Apgar score is lower in general than in spinal anesthesia; they suggested this difference due to transient sedation during general anesthesia [2]

The aim of this work was to evaluate if different modes of anesthesia affect fetal acid-base for cesarean sections.

PATIENTS AND METHODS

This cross-sectional study was conducted on newborns of 150 pregnant women of full-term babies aged 20 to 35 years with no previous maternal medical condition, undergoing elective caesarean section, at Ahmed Maher Teaching Hospital and Banha University Hospital from January 2022 till February 2023

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Inclusion criteria: Fetal factors (singleton, non-anomalous, no fetal distress; using cardiotocography (CTG), completed 37 weeks gestational age, and no placental abnormalities (e.g. placenta accreta, centralis……etc.).

Exclusion criteria: Women with maternal risk factors (hypertension, diabetes, etc) or taking medications, maternal age below 20 or above 35, previous maternal medical condition, twins, congenital anomalies, fetal distress using CTG, fetal age not completed 37, placental abnormalities (placenta accrete, centralis…. etc.), and rrefusal to participate in the study.

The included subjects were categorized into two equal groups: **SA group** where cesarean sections were done under spinal anesthesia and **GA group** where cesarean sections were done under general anesthesia.

Clinical picture of neonatal distress:

Recognized by one or more indicators of increased work of breathing, respiratory distress, such as nasal flaring, inability of breast feeding, tachypnea, low APGAR score, and hypoxemia, metabolic, chest grunting, or retractions and respiratory acidosis and respiratory alkalosis.

All neonates were subjected to postnatal history including Apgar score (severely depressed 0-3, moderately depressed 4-6, and excellent condition 7-10), complete history taking including (admission diagnosis, prenatal history, natal history, postnatal history, mode of delivery, gestational age, sex, family history, maternal history), general examination of the neonates including [measurements (weight, length and head circumference), vital signs (temperature, respiratory, heart rate, and blood pressure), and general condition and activity and neonatal reflexes (Moro and Suckling)], neurological examination including (mental status to assess the child's level of awareness and consciousness, motor function to check tone and joints, sensory perception to examine the child's ability to feel, and reflexes including Moro, suckling, grasp and pupil reflexes and systemic examination of chest, heart and abdomen. Cord blood samples were taken from participant newborns, and immediately after birth and the taken samples were sent for blood gas analysis.

Techniques of anesthesia:

General anesthesia: preoxygenated with 100% oxygen until end-tidal oxygen levels exceeded 70%, while the women were positioned in a left lateral tilt of 15–30°. Then, thiopentone (at 4–5 mg/kg) and suxamethonium (2 mg/kg) were utilised to induce rapid sequence initiation. Anesthesia was maintained with isoflurane, oxygen, nitrous oxide, and atracurium at a dose of 0.5 mg/kg subsequent to successful intubation.

Spinal anesthesia: adherence was given to a standard protocol involving intravenous fluid loading with 500 mL Hartmann solution. A left lateral spinal anaesthetic was administered using a spinal needle inserted at the L3/4 level. Subarachnoid space injections of 2 mL of 0.5 percent heavy bupivacaine, 15 μg of fentanyl, and 0.2 mg of morphine were subsequently administered. The fetal heart rate was monitored both prior to and subsequent to the induction of anesthesia. Following childbirth, the placental aspect of the divided umbilical cord was clamped twice, and pre-heparinized syringes were utilised to withdraw blood from one of the umbilical arteries. The syringes are transported to the laboratory immediately on ice. Printed copies of the results were gathered for analysis. From antenatal records, demographic information, pre-existing maternal conditions, and complications occurred prior to delivery.

The primary outcome was to assess and record cord blood gas values with different modes of anesthesia. The secondary outcomes were to assess effect of different modes of anesthesia on the following, Apgar score and neonatal outcome by modified Sarnat scoring for encephalopathy.

Ethical consideration:

The patient provided written consent that was informed. The research was approved from the ethical approval of the Ahmed Maher Teaching Hospital and Banha University Hospital (approval code: RC 5-1-2022).

Statistical analysis

An SPSS v28 statistical analysis was performed (IBM Inc., Armonk, NY, USA). The means and standard deviations (SD) of quantitative variables were provided, and the two groups were compared using a two-sample independent t-test. The frequency and percentage (%) of qualitative variables were utilised in the Chi-square test for analysis. In order to determine the degree of correlation between two quantitative variables, Pearson correlation was utilised. To evaluate the relationship between a dependent variable and one or more independent variables (univariate), logistic regression was also applied (multivariate). A two-tailed P value less than 0.05 was deemed to indicate statistical significance.

RESULTS

A statistically insignificant difference observed between the two groups regarding baseline data [age, gestational age, and reasons for cesarean section (voluntary, and other reasons)], umbilical cord arterial blood gas values [PCO_2, PH, Hco_3 and SO_2], Apgar score [at 10 min 1 min and 5 min after birth] , neonatal asphyxia, and fetal weight. **Table 1**

Table 1: Comparison between studied groups as regard baseline data, umbilical cord arterial blood gas values, Apgar score, neonatal asphyxia, and fetal weight

		GA group (n=75)	SA group (n=75)	P value
Age (years)		27.5±3.25	27.7±3.5	0.87
Gestational age (Weeks)		37.8±1.1	37.7±1.15	0.92
Reasons for cesarean section	**Voluntary**	30 (40%)	27 (36%)	0.42
	Other reasons	45 (60%)	48 (64%)	
Umbilical cord arterial blood gas values	**Ph**	7.14±0.28	7.33±0.19	0.85
	PCO_2 (mmHg)	47.34±4.15	45.77±9.6	0.75
	Hco_3 (%)	18.29±2.37	20.02±3.19	0.82
	SO_2 (%)	97.9±3.08	98.4±.96	0.90
Apgar score	**1 min after birth**	7.5±1.82	8.12±1.96	0.72
	5 min after birth	9.6±1.8	9.64±0.65	0.87
	10 min after birth	9.92±.49	9.96±.28	1
Neonatal asphyxia	**no asphyxia**	55 (73.33%)	56 (74.67%)	0.45
	Mild asphyxia	12 (16%)	12 (16%)	
	Severe asphyxia	8 (10.67%)	7 (9.33%)	
Fetal weight (g)		2974.8 ± 594.8	2924.1 ± 594.5	0.87

Data are presented as mean ± SD or frequency (%). PH: Potential hydrogen, PCO_2: Partial Pressure of Carbon Dioxide, Hco_3: Bicarbonate, SO_2: Oxygen saturation, *: P value <0.05 significant

Table 2 shows significant strong positive correlation between the outcomes and PH, PO_2 and PCO_2.

Table 2: Correlations between outcomes and different factors

		Outcomes
PH	**r**	0.495
	P	**<0.0001***
PO_2 (mmHg)	**r**	0.498
	P	**<0.0001***
PCO_2 (mmHg)	**r**	0.560
	P	**<0.0001***
HCT (%)	**r**	0.720
	P	**<0.0001***

PH: Potential hydrogen, PO_2: partial pressure of oxygen, PCO_2: partial pressure of carbon dioxide, HCT: Hematocrit Test, r: Correlation Coefficient, **: P value< 0.01 is highly significant,

Regarding univariate and multivariate correlations regression, there significant strong positive correlation between the outcomes and PH, PO_2 and PCO_2 (P value= <0.0001).

Table 3: Univariate and multivariate correlations regression between outcomes and different factors

		Univariate	Multivariate
PH	**Correlation**	0.348	0.348
	Significance	**<0.0001***	**<0.0001***
PO_2 (mmHg)	**Correlation**	0.471	0.471
	Significance	**<0.0001***	**<0.0001***
PCO_2 (mmHg)	**Correlation**	0.412	0.412
	Significance	**<0.0001***	**<0.0001***
Hct (%)	**Correlation**	0.357	0.357
	Significance	**<0.0001***	**<0.0001***

PH: Potential hydrogen, PO2: Partial Pressure of Oxygen, PCO2: Partial Pressure of Carbon Dioxide, HCT: Hematocrit Test, **: P value < 0.001: Statistically high significant difference.

DISCUSSION

The Cesarean section is currently one of the most frequently performed surgical procedures worldwide. Egypt occupied the third position globally in terms of reported Cesarean section rates, at 51.8 %, as indicated by the 2014 Egypt Demographic and Health Survey [5].

In the present study, it was found that the mean age of group GA, SA was 27.5±3.25 and 27.5±3.25 respectively, the average gestational age of both groups was 37.8±1.1 and 37.7±1.15 respectively. Age and gestational age do not differ significantly between the two groups (P = 0.87 and P = 0.92, respectively).

Mohamed *et al.* [6] showed that GA, SA age was 26.9 ±5.7 and 28.6 ±5.0 respectively, the mean gestational age of the two groups was 37.8 ±0.8 and 38.0 ±0.9 respectively. There is no statistically significant difference between the two groups as regard age (P= 0.171) and gestational age (P= 0.322).

The current investigation revealed that no statistically significant difference existed between the two cohorts as regard PH (P= 0.85), PCO_2(P= 0.75), Hco_3 (P= 0.82) and SO_2 (P= 0.90).

Mohamed *et al.* [6] documented a comparable trend in the pH of umbilical blood; the group undergoing general anesthesia had lower pH values (7.21) than the group undergoing spinal anesthesia (7.24); however, this difference did not reach statistical significance (p > 0.05). According to **Prikhodko *et al.*** [7], the average pH of the umbilical arterial blood in the group that underwent spontaneous vaginal delivery was 7.28 (0.09). This value was found to be significantly lower than the pH of 7.33 (0.08) observed in patients who underwent elective CS (p < 0.001). The levels of pCO2 and pO2 did not significantly differ in the groups of comparison. The 5% percentile pH was 7.12 in spontaneous vaginal delivery, which was lower than that in elective CS – 7.22. Revealed features of ABS indicate that there are metabolic changes in fetus experiencing labor stress due to the anaerobic metabolism. It was caused by transient hypoxemia due to reduced utero-placental circulation during uterine contractions [8]. At the same time, a reduction in pH and an elevation in BD are characteristic of all newborns who have experienced labor stress, regardless of whether the labor ended vaginally or by CS.

Free radical activity is significantly higher in neonates whose mothers breathe oxygen-enriched air, and this may have a significant impact on the premature prognosis and term infants who are compromised. Notably, the EA group exhibited a significantly greater base deficit, even though the outcome was typical. It is probable that, notwithstanding the preventive measures implemented, maternal hypotension and/or hypoperfusion of the uterus transpired in conjunction with EA, contributing significantly to a marginal augmentation in the fetal base deficit [9]. Conversely, the umbilical venous samples from the EA and SA groups exhibited a higher pH value. This finding implies that placental perfusion and exchange were enhanced, leading to the production of more typical pH levels. The venous samples exhibited comparable patterns of PO2, PCO2, HCO3, and base deficit values to the arterial values, which were significantly lower in the EA and SA groups. The underlying rationale for this observation is probably comparable [10].

Garzoli *et al.* [11] demonstrated that, with the exception of vaginal births performed under epidural anesthesia, this study found no significant differences in Apgar scores. These infants exhibited reduced Apgar scores at the 1- and 5-minute marks in comparison to those born without anesthesia. This finding aligns with our own observations, which documented compromised oxygenation of umbilical cord blood following a natural delivery utilising epidural anesthesia as opposed to a null delivery. On the contrary, **Beckmann *et al.*** [12] noted a significant decrease in pH within the GA group.

The current investigation revealed that there was no statistically significant difference between these two groups in terms of Apgar score at three time points: 10 minutes, 1 minute, and 5 minutes after birth.

Mohamed *et al.* [6] found no statistically significant difference between the two groups in terms of the APGER score one minute and five minutes and thirty seconds later (P=0.009, 0.029). **Thangaswamy *et al.*** [13] identified a correlation between GA for category 1 CS and a low Apgar score at 1 and 5 minutes. **Beckmann *et al.*** [12] conducted a retrospective cohort study on 533 term infants and found that infants born with category 1 GA CS had a significantly higher probability of achieving an Apgar score below 7 at 5 minutes. The study conducted by **Shek *et al.*** [10] revealed that the groups that received EA and SA exhibited slightly but significantly higher Apgar scores at the first minute (P < 0.001) and fifth minute (P = 0.003) in comparison to the group that received GA. However, for EA, SA, and GA, the number of neonates with Apgar scores less than seven at the first minute was one, one, and two, respectively, while none had an Apgar score less than seven at the fifth minute. This discovery is consistent with the assessment of the Cochrane review [2]. In their analysis of the outcomes of emergency caesarean sections, **Edipoglu *et al.*** [14] discovered that the reduced 1 minute Apgar scores were not reflected in the 5-minute Apgar scores or morbidity for the regional anesthesia group. In their study, **Harazim *et al.*,** [15] observed that there was no statistically significant difference in the 1st and 5th minute Apgar scores; however, regional anesthesia was associated with higher 1st and 5th minute Apgar scores.

The low incidence of fetal asphyxia, fetal distress, depression, and resuscitation during regional anesthesia can be readily attributed to the extremely active newborns. The observed discrepancies can be attributed to patient selection strategies, as our research excluded pregnancies in which fetal abnormalities were suspected, thereby mitigating the potential for adverse events. The 1 minute and 5 minute Apgar scores did not differ between cases of regional and general anesthesia,

according to subsequent research [16]. Because maternal anesthetics cross the placental barrier and enter fetal circulation, they hypothesized that newborns delivered under general anesthesia would experience transient respiratory depression.

In the current investigation, the average fetal weight in the GA group was determined to be 2974.8 ± 594.8. The fetal weight in the SA group was 2924.1 ± 594.5 on average. The fetal weight of the two groups does not differ in a statistically significant manner.

In their study, **Mohamed Amin *et al.*** [6] discovered that the fetal weight difference between the two groups (3.2 ±0.5 vs 3.4 ±0.6) was not statistically significant (P = 0.138). According to **Szymanowski *et al.*** [17] the mean birth weight for Group 1 was 3468 ± 332 (SD), Group 2 was 3461 ± 359 (SD), Group 3 was 3442 ± 340 (SD), and Group 4 was 3462 ± 346 (SD) (SD). No statistically significant differences in birth weight were observed among the aforementioned groups.

The results of the current investigation revealed a statistically significant and robust positive correlation between the variables of PH, PO2, and PCO2.

According to **Shek *et al.*** [10], spinal anesthesia was found to be correlated with the highest pH in umbilical venous blood, and the group that received spinal anesthesia also had the highest base excess in umbilical venous samples. These findings suggest that there is a significant relationship between the type of anesthesia and fetal acid-base status. However, the specific correlation between the outcomes and PH, PO_2 and PCO_2 was not explicitly mentioned in the search results. Further examination of the individual studies may provide more detailed information on the correlation between these factors.

Limitations: Limited sample size and single-center design of our study, we were unable to analyse maternal and fetal cord blood for reactive oxygen species because our institute lacked the necessary testing equipment. Nevertheless, the clinical impact of elevated reactive oxygen species on the foetus remains unproven, and the long-term consequences of intrauterine hypoxia on the baby's developmental trajectory have not been examined or investigated.

We recommended providing a larger sample with multi-center cooperation to validate and generalize our results and a follow up period to investigate the baby developmental progress. Further research is recommended to study the correlation between acid-base parameters with general and spinal anesthesia.

CONCLUSIONS

It could be concluded that umbilical cord arterial blood gas values, Apgar score (at 1, 5 and 10 min after birth) and neonatal asphyxia are comparable between the two different modes of anesthesia (spinal and general). Moreover, there are significant strong positive correlations between the outcomes and PH, PO_2, and PCO_2, and they are also strong predictors of neonatal outcomes.

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