

Correlação entre a Fração Inspirada de Oxigênio, a Pressão Parcial de Oxigênio Materno e a Pressão Parcial de Oxigênio Fetal durante Parto Cesáreo em Gestações Normais *

Correlation between the Inspired Fraction of Oxygen, Maternal Partial Oxygen Pressure, and Fetal Partial Oxygen Pressure during Cesarean Section of Normal Pregnancies

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RESUMO

Castro CHV, Cruvinel MGC, Carneiro FS, Silva YP, Cabral ACV, Bessa RC - Correlação entre a Fração Inspirada de Oxigênio, a Pressão Parcial de Oxigênio Materno e a Pressão Parcial de Oxigênio Fetal durante Parto Cesáreo em Gestações Normais.

JUSTIFICATIVA E OBJETIVOS: Apesar das alterações na função pulmonar, a oxigenação materna se mantém nas anestésias regionais para obstetria. Mesmo assim, nessas situações, o fornecimento de oxigênio suplementar para a mãe é prática disseminada. A principal justificativa é a boa oxigenação fetal; entretanto, não há devida comprovação. Este estudo prospectivo e com distribuição randômica das pacientes teve o objetivo de testar a hipótese da existência ou não de correlação entre hiperóxia materna e elevação de parâmetros gasométricos fetais na cesariana eletiva.

MÉTODO: Foram estudadas vinte pacientes grávidas, submetidas à raqui-anestesia, através de gasometrias arteriais, com diferentes frações inspiradas de oxigênio e correlacionadas com a gasometria fetal.

RESULTADOS: O aumento da fração inspirada de oxigênio materno não se correlacionou com o aumento da pressão parcial de oxigênio fetal.

CONCLUSÕES: A indução de hiperóxia materna através de oxigenoterapia suplementar não foi capaz de aumentar a pressão parcial de oxigênio no feto. Não houve modificação nos parâmetros gasométricos fetais, mesmo em caso de mudança desses

parâmetros na parturiente, induzidos pela hiperóxia durante a cesariana sob raqui-anestesia.

Unitermos: CIRURGIA, Obstétrica: cesariana; FISILOGIA, Transporte de oxigênio, Oxigenação fetal

SUMMARY

Castro CHV, Cruvinel MGC, Carneiro FS, Silva YP, Cabral ACV, Bessa RC - Correlation between the Inspired Fraction of Oxygen, Maternal Partial Pressure of Oxygen, and Fetal Partial Oxygen Pressure During Cesarean Section of Normal Pregnancies.

BACKGROUND AND OBJECTIVES: Despite changes in pulmonary function, maternal oxygenation is maintained during obstetric regional blocks. But in those situations, the administration of supplementary oxygen to parturients is a common practice. Good fetal oxygenation is the main justification; however, this has not been proven. The objective of this randomized, prospective study was to test the hypothesis of whether maternal hyperoxia is correlated with an increase in fetal gasometric parameters in elective cesarean sections.

METHODS: Arterial blood gases of 20 parturients undergoing spinal block with different inspired fractions of oxygen were evaluated and correlated with fetal arterial blood gases.

RESULTS: An increase in maternal inspired fraction of oxygen did not show any correlation with an increase of fetal partial oxygen pressure.

CONCLUSIONS: Induction of maternal hyperoxia by the administration of supplementary oxygen did not increase fetal partial oxygen pressure. Fetal gasometric parameters did not change even when maternal parameters changed, induced by hyperoxia, during cesarean section under spinal block.

Keywords: PHYSIOLOGY, Oxygen transport, Fetal oxygenation; SURGERY, Obstetric: cesarean section

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INTRODUCTION

The use of supplementary oxygen in general anesthesia became routine in the decade of 1960 ¹. Despite the changes in pulmonary function seen in regional blocks (epidural and subarachnoid) used in obstetrics, maternal oxygenation is maintained and a rational explanation to administer supplementary oxygen to the mother has not been established ²⁻⁵. In 1984, Crawford in his textbook stated that it is recommendable to administer supplementary oxygen to the parturient, and this recommendation was disseminated in clinical practice mainly for reasons related to the fetus, but without being properly proved⁶. The objective of this study was to analyze whether maternal hyperoxia generated by high oxygen inspired fraction is capable of increasing fetal partial oxygen pressure during cesarean section of normal pregnancies.

METHODS

After approval by the Ethics on Research Committee and signing of the informed consent, 20 parturients at term (38 to 41 weeks), scheduled for cesarean section participated in this randomized, prospective study. Patients were divided in two groups: study (group 1), composed of 12 parturients who underwent intraoperative hyperoxia; and control (group 2), composed of eight parturients who underwent cesarean section without supplementary oxygen

Table I shows the distribution by age, gestational age, and number of pregnancies of the studied patients. Exclusion criteria were as follows:

- Maternal disease with repercussions in fetal oxygenation (preeclampsia, hypertension, pulmonary disease, cardiac disease with shunt, and diabetes mellitus types 1 and 2).
- Presence of intraoperative intercurrents that compromised fetal oxygenation (hypertension not compensated by the therapeutic maneuvers described, fetal extraction time > 3 minutes).

Patients were admitted to the operating room without pre-anesthetic medication, monitored with electrocardiogram

Table I – Distribution of Parturients According to the Following Characteristics: Age, Number of Pregnancies, and Gestational Age

	Number	%
Number of pregnancies		
Primipara	7	35
Second pregnancy	8	40
Multiparous	5	25
Age		
20-25	3	15
26-30	8	40
31-35	4	20
36-40	5	25
Gestational age		
38 weeks	6	30
39 weeks	11	55
40 weeks	3	15
41 weeks	0	0

(ECG), peripheral oxygen saturation (SpO₂), non-invasive blood pressure (NIBP) with one-minute intervals until delivery followed by measurements every three minutes until the end of the procedure. An 18G catheter was used for venoclysis in an upper limb. Patients were hydrated with Ringer's lactate warmed to 37° C administered rapidly at 15 mL.kg⁻¹ before the anesthetic blockade. After antisepsis (according to the recommendations of the Hospital Infection Control Commission (CCIH, from the Portuguese), the skin was infiltrated with 2% lidocaine, followed by puncture of the subarachnoid space with a pencil tip 27G needle with the patient in the sitting position. This was followed by the subarachnoid administration of 0.5% heavy bupivacaine 10 mg, associated with 60 µg of morphine. After the regional block, patients were placed in dorsal decubitus and the uterus was moved manually to the left. Hypotension was defined as a reduction in blood pressure greater than 20% from control levels or lower than 100 mmHg. Hypotension was treated with boluses of 5 to 10 mg of ephedrine until it reached normal levels. Reductions in SpO₂ below 92% were treated immediately with supplementary oxygen and the patient was removed from the study. Dexamethasone 8 mg, was administered before anesthesia to prevent nausea and vomiting. Nausea and vomiting were treated with metochlopramide 10 mg, after hypotension was ruled out.

Blood samples were collected from the umbilical cord before placental expulsion and before the onset of neonatal respiratory movements. The umbilical cord was clamped

proximal and distally, and the umbilical vein was punctured to collect blood samples. Maternal arterial blood gases were measured twice: before the administration of oxygen or compressed air and 10 minutes after the administration of oxygen or compressed air. Blood samples were packed in ice and sent immediately to the laboratory. The syringes contained enough heparin to fill the dead space of the syringe. The following parameters were measured in all blood samples: pH, PaO₂, CO₂, and bicarbonate.

Two groups of patients were investigated: one (study) received supplementary oxygen using an inspired oxygen fraction (FiO₂) equal or greater than 0.6; the other group (control) received room air, i.e., a FiO₂ of 0.21. The FiO₂ to be administered was determined randomly using a table sealed in an envelope. It was determined by the mixer of the anesthesia device and the reading was confirmed by the oximeter of the anesthesia equipment⁷. Oxygen was delivered through a mask with reservoir.

The Kruskal-Wallis test was used to compare age, pre- and postoperative PaO₂, fetal PaO₂, and PaO₂ ratio (Post-PaO₂/pre-PaO₂ x 100) between both groups. This non-parametric test compares two or more independent samples (in this case, use of oxygen or not) in relation to a parameter of interest that is at least ordinal. The non-parametric test Wilcoxon was used to compare pre- and postoperative PaO₂ in each group (use of oxygen or not). Due to the difficulty to undertake the study, which is reflected in the small number of patients, it was decided to use non-parametric tests since the confirmation of normalcy of the data can be hindered by the small number of study patients. Besides, Spearman test (non-parametric) was used to assess the relationship among parameters of interest. Results were considered significant at the 5% level (p < 0.05).

RESULTS

Table II shows the statistically significant difference (p < 0.05) in post-PaO₂ and PaO₂ ratio (%) between the group that used oxygen and the group that did not use oxygen. In both cases, the PaO₂ of patients who used oxygen was significantly higher than that of the patients who did not use oxygen. Note that the age of the patients did not differ significantly. A significant difference (p < 0.05) was observed when pre- and postoperative PaO₂ among patients who used oxygen were compared, in which postoperative PaO₂ was significantly higher than preoperative measurements. However, pre- and postoperative PaO₂ did not show significant differences (p > 0.05) among patients who did not receive oxygen. As can be seen in table IV, maternal and fetal PaO₂ did not show significant differences, regardless of whether or not oxygen was used; therefore, maternal PaO₂ did not determine fetal PaO₂. One patient in the study group developed post-dura mater puncture headache.

Table II – Descriptive and Comparative Analysis between the Oxygen and No Oxygen Groups According to Age, pre-PaO₂, post-PaO₂, fetal PaO₂ e PO₂ Ratio

Parameter	Use of O ₂	n	Descriptive measurements					P*
			Minimal	Maximum	Median	Mean	SD	
Age	Yes	12	27.0	41.0	32.5	33.1	4.9	0.054
	No	8	24.7	39.0	27.0	28.5	4.9	Yes = No
Pre-PaO ₂	Yes	12	90.0	132.0	107.0	109.5	13.7	0.105
	No	8	72.0	122.0	97.0	97.4	15.2	Yes = No
Post-PaO ₂	Yes	12	190.0	294.0	227.5	237.8	37.6	< 0.001
	No	8	95.0	146.0	104.5	114.1	21.1	Yes > No
Fetal PaO ₂	Yes	12	23.0	47.0	28.0	30.8	7.1	0.670
	No	8	26.0	38.0	30.0	30.1	3.6	Yes = No
PO ₂ ratio	Yes	12	167.5	276.2	219.5	218.9	34.1	< 0.001
	No	8	77.9	154.4	117.9	119.4	26.1	Yes > No

*p refers to the Kruskal-Wallis test
 PO₂ Ratio = (post-PaO₂ / pre-PaO₂) × 100

Table III – Descriptive and Comparative Analysis of Pre- and Post-Treatment Maternal PaO₂ According to the Use of Oxygen or Not

Use of oxygen	PaO ₂	n	Minimal mmHg	Maximal mmHg	Median mmHg	Mean mmHg	SD	p*
Yes	Pre	12	90.0	132.0	107.5	109.5	13.7	0.003
	Post	12	190.0	294.0	227.5	237.8	37.6	Post > Pre
Difference (post-pre)		12	77.0	178.0	122.5	128.4	35.0	-
No	Pre	8	72.0	122.0	97.0	97.4	15.2	0.080
	Post	8	95.0	146.0	104.5	114.1	21.1	Post = Pre
Difference (post-pre)		8	-27	50	13.5	16.7	25.3	-
Fetal PO ₂	Yes	12	23.0	47.0	28.0	30.8	7.1	0.670
	No	8	26.0	38.0	30.0	30.1	3.6	Yes = No

*p refers to the Wilcoxon test

Table IV – Analysis of the Correlation between Maternal and Fetal post-PaO₂

Oxygen	R	p*
Yes	0.407	0.189
No	0.401	0.324

*p refers to the Spearman correlation

DISCUSSION

During the decade of 1960, the use of supplementary oxygen became routine in general anesthesia ¹. In obstetric regional blocks (epidural and subarachnoid), maternal oxygenation is

maintained despite changes in pulmonary function; a rational justification to administer supplementary oxygen to the mother has not been established. In 1984, Crawford, in his text book, stated that the administration of supplementary oxygen to the mother is recommendable mainly for fetal reasons, but without supportive evidence⁶. Marx and Mateo ⁸ demonstrated the relationship between maternal and fetal oxygen pressure (PaO₂) in general anesthesia. Analysis of the present study was hindered since hypoxic parturients were included⁸. Ramanathan et al. ⁹ repeated in essence the work of Marx and Mateo, but patients received epidural anesthesia and hypoxic women were excluded. There was a correlation between maternal and fetal PaO₂, but fetal Apgar and pH did not show differences. At first, those results seem to

indicate that the administration of supplementary O₂ to the mother is rational; however, the difference observed was not statistically significant.

Therefore, it is adequate to ask: if maternal hyperoxia does not induce favorable changes in the fetus, can it be harmful? The possibility that maternal hyperoxia can close the ductus arteriosus, which could affect the fetal circulation and the first moments of life, is one of the established concerns. Clinical experience shows that this is a theoretical risk that is ignored in clinical practice. Khaw et al.¹⁰ undertook a study with women undergoing elective cesarean section under subarachnoid block randomly divided in two groups: one in room air and the other with supplementary O₂. They analyzed maternal and fetal arterial blood gases and fetal markers of free radicals. The results showed a clear difference between both groups; the levels of free radical were higher in the women who received supplementary oxygen. This imposes a new question: the increased activity of free radical markers is a marker for fetal morbidity?

Current knowledge does not allow the correlation between the activity of free radicals to an increase in fetal morbidity in parturients undergoing elective cesarean section. Khaw et al.¹⁰ stated that in low risk situations (for example, elective cesarean section) a favorable result would not, probably, be influenced negatively by maternal hyperoxia. However, this report could influence premature fetuses or those with some degree of distress. Recent studies reported better results in newborns resuscitated with room air when compared to those treated with oxygen^{11,12}. Those results have had a considerable influence on clinical practice and therefore the manual of neonatal resuscitation revoked the recommendation to administer oxygen.

Will the present study and the ones mentioned above change obstetric anesthesiology regarding the administration of supplementary oxygen? Justifying the administration of supplementary oxygen to parturients with the following statements might change: a) the oxygen is for the fetus; b) if supplementary oxygen does not improve, at least it is not harmful; c) oxygen is for severely ill patients. This study showed that supplementary oxygen did not bring any benefits in the situations mentioned, since it did not cross into the fetal blood. Although the use of oxygen in critical situations for the fetus and mother is almost a conditioned reflex of anesthesiologists, this behavior is weakened by recent evidence that the excessive use of oxygen might be associated with some damage, especially in fetal distress.

The waist of resources is another important aspect that might be brought into the discussion. Chart I shows the number of abdominal deliveries in 2001 and 2002 (DATASUS, 2004). If a cesarean section lasts a mean of one hour and the price of oxygen varies from approximately US\$2.37* to US\$5.39* per hour, one can infer that by not using oxygen, one would decrease costs by US\$2,820,000.00 to US\$6,350,000.00. If we add the nasal catheter, the yearly cost would be decreased by US\$3,200,000.00 to

Chart I – Number of Cesarean Sections in Brazil per Region*

Region	Number of cesarean sections	
	2001	2002
North	79,929	83,297
Northeast	240,949	243,927
Southeast	574,339	566,328
South	178,743	177,911
Central West	100,041	100,269
	1,174,044	1,171,732

* Estimated number for live births

US\$6,700,000.00. A developing country cannot ignore those sums. Oxygen prices were furnished by the pharmacy of a hospital in Belo Horizonte and refer to the maximal and minimal prices for the public health system in 2005.

Finally, we should try to understand why fetal oxygen did not increase despite the elevation in maternal PaO₂. Similarly to the present study, Kelly et al.⁵ and Cogliano et al.¹³ administered 35% and 40% oxygen, respectively, and it did not increase oxygen concentration in fetal blood. The authors concluded that this lack of fetal repercussion might be due to an intraplacental arteriovenous shunt, which might be responsible for not using the additional oxygen offered by the mother to the intervillous space, resulting in the return of excess oxygen to the maternal blood circulation. This hypothesis is supported by the study of Schaaps¹⁴ in which the level of maternal PaO₂ was 93 mmHg, while that of the fetus was 19 mmHg in the umbilical vein, which is significantly lower than that of the intervillous space (29.2 mmHg).

Summarizing, one can state that induction of maternal hyperoxia by using supplementary oxygen is not capable of increasing fetal partial oxygen pressure and that fetal gasometric parameters do not change, even when those parameters change in the mother induced by maternal hyperoxia in cesarean sections under subarachnoid block.

The present study has important limitations. Using procedures such as arterial puncture and collecting umbilical cord blood make parturients insecure, hence the reduced number of patients and its impact on the statistical analysis. Therefore, the lack of an impact of maternal hyperoxia in fetal oxygenation, along with the economy of resources identified, justify further studies with a larger study population.

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RESUMEN

Castro CHV, Cruvinel MGC, Carneiro FS, Silva YP, Cabral ACV, Bessa RC - Correlación entre la Fracción Inspirada de Oxígeno, la Presión Parcial de Oxígeno Materno y la Presión Parcial de Oxígeno Fetal Durante el Parto por Cesárea en Embarazos Normales.

JUSTIFICATIVA Y OBJETIVOS: *A pesar de las alteraciones en la función pulmonar, la oxigenación materna se mantiene en las anestésias regionales para obstetricia. Pero incluso así, en esas situaciones, el suministro de oxígeno suplementario para la madre se practica en forma diseminada. La principal justificación es la buena oxigenación fetal, sin embargo, no existe la debida comprobación al respecto. Este estudio prospectivo y con distribución randómica de las pacientes, tuvo el objetivo de comprobar la hipótesis de la existencia o no de una correlación entre la hiperoxia materna y la elevación de los parámetros gasométricos fetales en la cesárea por elección.*

MÉTODO: *Se estudiaron veinte pacientes embarazadas, sometidas a la raquianestesia, a través de gasometrías arteriales, con diferentes fracciones inspiradas de oxígeno y correlacionadas con la gasometría fetal.*

RESULTADOS: *El aumento de la fracción inspirada de oxígeno materno no se correlacionó con el aumento de la presión parcial de oxígeno fetal.*

CONCLUSIONES: *La inducción de hiperoxia materna a través de la oxigenoterapia suplementaria, no fue capaz de aumentar la presión parcial de oxígeno en el feto. No hubo modificación en los parámetros gasométricos fetales, incluso en el caso del cambio de esos parámetros en la parturiente, inducidos por la hiperoxia durante la cesárea bajo raquianestesia.*