

Preoxygenation for Cesarean Section: A Comparison of Two Techniques

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Preoxygenation is routine prior to rapid-sequence induction of general anesthesia for cesarean section. A common method of preoxygenation is 3–5 min of 100% O₂ breathing. In some obstetric emergencies, such as fetal distress, there may not be adequate time for preoxygenation using this technique. Recently, Gold *et al.*¹ showed that four maximally deep inspirations of 100% O₂ within 30 s are as effective as 5 min of inhalation of 100% O₂ in increasing PaO₂ in the non-pregnant patient. The use of this technique in the parturient and its effect on the fetus have not been studied. We, therefore, wished to show that the four-deep-breath, 30-s technique is safe and effective for both mother and fetus.

METHODS

The Clinical Research Practices Committee approved the protocol. Twenty ASA I and II patients scheduled for elective cesarean section under general anesthesia participated in the study, and all patients gave written informed consent. Following premedication with 30 ml 0.3 M sodium citrate, we randomly divided the patients into two groups: Group A was denitrogenated by breathing 100% O₂ for 3 min; Group B was denitrogenated by taking four maximally deep inspirations of 100% O₂ within 30 s. We administered O₂ to both groups at a flow rate of 5–6 l·min⁻¹ via a circle anesthesia system and a tight-fitting face mask. We performed a rapid-sequence induction of general anesthesia with thiopental 3.5 mg·kg⁻¹ iv followed by succinylcholine 1.2 mg·kg⁻¹ iv and intubated the trachea during cricoid pressure. Anesthesia was maintained with 50% nitrous oxide in oxygen and 0.5% halothane until delivery. Paralysis was provided with a 0.1 mg·ml⁻¹ infusion of succinylcholine. Ventilation was controlled to maintain end-tidal CO₂

between 4.0 and 4.5%. Three arterial blood samples were drawn from a previously placed 20 gauge arterial catheter: baseline (room air), after preoxygenation, and following intubation. We sampled umbilical cord obtained at delivery. All blood samples were immediately placed on ice and analyzed within 20 min.

We compared the groups for maternal age, weight, height, hemoglobin, smoking history, and weeks gestation. Induction to delivery and uterine incision to delivery intervals and neonatal weights were recorded. A pediatric resident, unaware of the study, assigned Apgar scores. Maternal blood gas values were analyzed using a combined analysis of variance for repeated measures.² Other data were analyzed using the Student's *t* test or chi-squared as appropriate. All values are expressed as mean ± SEM and a *P* < 0.05 was considered significant.

RESULTS

The two groups were similar in age, weight, height, hemoglobin, and weeks gestation (table 1). There were five smokers in Group A and three smokers in Group B. Induction to delivery times and uterine incision to delivery times were similar (table 1).

Maternal blood gas values are shown in table 2. There were no differences in maternal blood gas values between the two groups at any time.

Neonatal outcomes were also similar. Neonatal weight was 3.3 ± 0.2 kg in Group A and 3.4 ± 0.2 kg in Group B. No infant had an Apgar score of less than 7 at 1 or 5 min. Umbilical artery and venous blood gas values were similar in the groups (table 2).

TABLE 1. Patient Data

	Group A* (3 min) (n = 10)	Group B* (4 breath) (n = 10)
Age (yr)	25.3 ± 1.9	23.7 ± 1.7
Weight (kg)	75.0 ± 3.8	73.4 ± 4.1
Height (cm)	163.7 ± 2.5	155.7 ± 2.4
Hemoglobin (g/dl)	11.4 ± 0.4	12.5 ± 0.5
Gestation (wk)	38.9 ± 0.2	38.3 ± 0.5
No. smokers	5	3
Induction to delivery (min)	7.1 ± 0.8	5.6 ± 0.5
Uterine incision to delivery (s)	75.5 ± 7.9	66.6 ± 11.9

* Values are mean ± SEM.

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TABLE 2. Blood Gas Values

	Group A* (3 min) (n = 10)	Group B* (4 breath) (n = 10)
Baseline		
pH	7.44 ± 0.0	7.44 ± 0.01
PaCO ₂	31.4 ± 0.7	31.7 ± 0.5
PaO ₂	100.9 ± 3.1	102.5 ± 1.5
After Preoxygenation		
pH	7.44 ± 0.01	7.46 ± 0.01
PaCO ₂	31.9 ± 0.4	31.7 ± 0.8
PaO ₂	385.0 ± 23.6*	404.2 ± 15.2*
Following intubation		
pH	7.37 ± 0.0†	7.37 ± 0.01†
PaCO ₂	40.0 ± 0.7†	40.6 ± 0.7†
PaO ₂	270.9 ± 33.7†	305.8 ± 24.5†
Umbilical		
pH	7.35 ± 0.01	7.36 ± 0.01
P _{CO₂}	43.5 ± 1.6	43.6 ± 1.0
P _{O₂}	33.9 ± 1.9	37.8 ± 2.3
Umbilical artery		
pH	7.31 ± 0.01	7.33 ± 0.01
P _{CO₂}	50.7 ± 1.5	50.7 ± 0.7
P _{O₂}	17.8 ± 1.4	22.0 ± 1.4

* Values are mean ± SEM.

† P < 0.01 versus baseline.

‡ P < 0.01 versus after preoxygenation.

DISCUSSION

Oxygenation during anesthesia has been studied for many years. Dillion and Darsie⁴ observed that significant desaturation of arterial blood occurs during the apnea that accompanies thiopental induced anesthesia. They noted that oxygen administration avoided this desaturation and recommended 5 min of preoxygenation before induction and endoscopy. Hamilton and Eastwood⁵ showed that denitrogenation was 95% complete within 2–3 min of tidal breathing using a circle anesthesia system with a 5 l·min⁻¹ flow. These studies led to the recommendation in standard anesthesia texts of 3–5 min preoxygenation prior to rapid-sequence induction of anesthesia.^{6,7} Heller and Watson⁸ showed, in a spontaneously ventilating nonpregnant patient that 3–4 min of 100% oxygen breathing are required to increase PaO₂ from 78 to greater than 300 mmHg. However, in an artificially ventilated patient, the PaO₂ increased from 95 to higher than 400 mmHg within 30 s. These observations led Gold *et al.*¹ to develop and study the four-deep-breath, 30-s technique of preoxygenation. They demonstrated that arterial oxygen tension in normal unanesthetized patients is similar after four maximally deep inspirations within 30 s and after 5 min of 100% oxygen breathing. Although Archer and Marx⁹ found that the reduction in oxygen tension during apnea under general anesthesia is significantly greater in pregnant women than in nonpregnant controls, in some emergency circumstances, there is not sufficient time

for a full 3–5 min of preoxygenation and the four-deep-breath, 30-s technique would be useful.

Pregnancy produces significant anatomic functional changes in the respiratory system, which may alter the response of the parturient to the four-deep-breath, 30-s technique. While total lung capacity remains unchanged, there is a decrease in expiratory reserve volume and residual volume, resulting in an overall 9.5–25% decrease in functional residual capacity (FRC).^{10–13} These changes decrease the parturient's oxygen reserve at end expiration and this, associated with the increase in oxygen consumption seen in pregnancy,¹⁰ means the parturient rapidly becomes hypoxemic during periods of apnea.⁹ However, this decrease in FRC also decreases nitrogen reserve in the lung, and nitrogen washout should occur more rapidly than in the nonpregnant patient. The role of airway closure also must be considered. While studies of closing capacity (CC) or closing volume conflict, most investigators find a decrease in the difference between FRC and CC such that airway closure occurs more frequently in the pregnant patient during tidal breathing,^{12–16} especially when supine.^{13,14,17,18} Continued perfusion of these now under-ventilated alveoli may explain the supine hypoxemia and increased alveolar–arterial oxygen tension difference seen in some parturients at term.¹⁸ In such a patient in whom CC does encroach upon FRC while supine, the four-deep-breath, 30-s technique may be expected to improve oxygenation by increasing tidal volume and reexpanding previously under-ventilated alveoli. Our data are consistent with these suppositions.

We also felt it important to assess the effect of the four-deep-breath, 30-s technique on fetal oxygenation. Investigators have shown that increased umbilical P_{O₂} correlates significantly with improved fetal outcome as measured by Apgar scores, time to sustained respiration, or umbilical acid–base status.^{19–21}

Shelley and Gutsche²² state that 6 min of oxygen inhalation is required for equilibration of maternal/fetal oxygen levels. The four-deep-breath, 30-s technique may expose infants to increased oxygen levels for less than 6 min, however, work by other investigators suggests that less time is needed for maternal oxygen inhalation to affect fetal P_{O₂}.^{23,24} Myers *et al.*,²³ studying Rhesus monkeys, showed that maternal administration of oxygen increases fetal tissue P_{O₂} beginning within 60 s and equilibrating with 3 min. Longo and Power²⁴ constructed a systems model of placental O₂ transfer and suggest that fetal oxygen levels completely respond within 75 s to changes in umbilical oxygen supply. The patients in the four-deep-breath, 30-s group were exposed to oxygen for a mean of 6 min before delivery, and their infants had an umbilical vein P_{O₂} (37.8 ± 2.3 mmHg) similar to that of the infants in the 3-min group

(33.9 ± 1.9 mmHg) whose mothers were exposed to oxygen for at least 10 min before delivery. In one case, the total time from preoxygenation to delivery was only 3 min and the umbilical vein P_{O₂} was 41.4 mmHg. These results agree with those of Myers *et al.*²³ and Longo and Power²⁴ and demonstrate that in the normal situation fetal P_{O₂} responds rapidly to changes in maternal Pa_{O₂}. In circumstances of fetal distress, there are often severe limitations on the amount of oxygen that can be transferred to the fetus with any technique of preoxygenation and our prime concern is to maintain adequate maternal oxygenation during the apnea that accompanies induction and intubation.

In conclusion, we have shown that in the parturient both 3 min of oxygen breathing and the four-deep-breath, 30-s technique are adequate for preoxygenation prior to rapid sequence induction of general endotracheal anesthesia for cesarean section. We have also shown that both techniques provide similar fetal outcomes. Therefore, the four-deep-breath, 30-s technique can be used safely for routine obstetric anesthetics and may be particularly useful in the parturient who is unable to tolerate a close-fitting face mask for a prolonged period of time. However, we believe that its main application should be in those situations, such as acute fetal distress, where time is of the essence.

REFERENCES

1. Gold MI, Durate I, Muravchick S: Arterial oxygenation in conscious patients after 5 minutes and after 30 seconds of oxygen breathing. *Anesth Analg* 60:313-315, 1981
2. Hull CH, Nie N (eds): *Statistical package for the Social Sciences Update*, 7-9. New York, McGraw-Hill, 1981
3. Heller ML, Watson TR Jr: Arterial oxygenation during transition from 100 percent oxygen to air breathing: Polarographic Pa_{O₂} study. *ANESTHESIOLOGY* 22:385-392, 1961
4. Dillion JB, Darsie ML: Oxygen for acute respiratory depression due to administration of thipental sodium. *JAMA* 159: 1114-1116, 1955
5. Hamilton WK, Eastwood DW: A study of denitrogenation with some inhalation anesthetic systems. *ANESTHESIOLOGY* 16: 801-807, 1955
6. Giesecke AH Jr: Anesthesia for trauma surgery, *Anesthesia*. Edited by Miller RD. New York, Churchill Livingstone, 1981, pp 1247-1263
7. Shnider SM, Levinson G: *Anesthesia for cesarean section, Anesthesia for Obstetrics*. Edited by Shnider SM, Levinson G. Baltimore, Williams and Wilkins, 1979, pp 257-275
8. Clark LC, Wolf R, Granger D, Taylor Z: Continuous recording of blood oxygen tensions by polarography. *J Appl Physiol* 6: 189-193, 1953
9. Archer GW, Marx GF: Arterial oxygen tension during apnoea in parturient women. *Br J Anaesth* 46:358-360, 1974
10. Cugell DW, Frank NR, Gaensler EA, Badger TL: Pulmonary function in pregnancy. *Am Rev Tuberc* 67:568-597, 1953
11. Eng M, Butler J, Bonica JJ: Respiratory function in pregnant obese women. *Am J Obstet Gynecol* 123:241-245, 1975
12. Baldwin GR, Moorthi DS, Welton JA, Mac Donnell KF: New lung functions and pregnancy. *Am J Obstet Gynecol* 127: 235-239, 1977
13. Craig DB, Toole MD: Airway closure in pregnancy. *Can Anaesth Soc J* 22:665-672, 1975
14. Bevan DR, Holdcroft A, Loh L, MacGregor WG, O'Sullivan JC, Sykes MK: Closing volume and pregnancy. *Br Med J* 1: 13-15, 1974
15. Holdcroft A, Bevan DR, O'Sullivan JC, Sykes MK: Airway closure and pregnancy. *Anaesthesia* 32:517-523, 1977
16. Garrard GS, Littler WA, Redman CWG: Closing volume during normal pregnancy. *Thorax* 33:488-492, 1978
17. Ang CK, Tan TH, Walters WAW, Wood C: Postural influence on maternal capillary oxygen and carbon dioxide tension. *Br Med J* 4:201-203, 1969
18. Awe RJ, Nicotra MB, Newsom TD, Viles R: Arterial oxygenation and alveolar-arterial gradients in term pregnancy. *Obstet Gynecol* 53:182-186, 1979
19. Rorke MJ, Davey DA, DuToit HJ: Foetal oxygenation during caesarean section. *Anaesthesia* 23:585-596, 1968
20. Marx GF, Mateo CV: Effects of different oxygen concentrations during general anaesthesia for elective caesarean section. *Can Anaesth Soc J* 18:587-593, 1971
21. Fox GS, Smith JB, Namba Y, Johnson RC: Anesthesia for cesarean section: Further studies. *Am J Obstet Gynecol* 133: 15-19, 1979
22. Shelly WC, Gutsche BB: *Anesthesia for the febrile parturient, obstetric anesthesia: The complicated patient*. Edited by James FM III, Wheeler AS. Philadelphia, FA Davis, 1982, pp 297-316
23. Myers RE, Stange L, Joelsson I, Huzell B, Wussow C: Effects upon the fetus of oxygen administration to the mother. *Acta Obstet Gynecol Scand* 56:195-203, 1977
24. Longo LD, Power GG: Placental oxygen transfer: A systems approach. *Rev Perinat Med* 1:1-34, 1976