Maternal inspired oxygen concentration and fetal oxygenation during Caesarean section

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This study was designed to determine whether fetal arterial and venous PO₂ could be increased by increasing maternal FIO₂ in the period between hysterotomy and birth. Two groups of ten patients were studied. All were anaesthetised with the same technique except for the FIO₂ after hysterotomy. One group inspired 50% oxygen and the second group inspired 100% oxygen. Although the maternal arterial PO₂ was higher at birth in the 100% O₂ group (177.4 ± 42.3 mmHg vs 281.0 ± 94.2 mmHg), there were no differences between the arterial umbilical cord PO₂ (19.3 ± 5.7 mmHg vs 18.5 ± 7.3 mmHg) and the venous umbilical cord PO₂ (31.1 ± 7.6 mmHg vs 33.0 ± 10.8 mmHg). Awareness was present in one patient in the 50% O₂ group and in four patients in the 100% O₂ group but this difference was not statistically significant. It is concluded that a higher inspired maternal oxygen concentration between hysterotomy and birth does not result in any increase in fetal PO₂.

La présente étude a été menée pour déterminer si les PO₂ veineuses et artérielles foetales augmenteraient en augmentant la FIO₂ maternelle entre l'hystérotomie et la naissance. Deux groupes de dix patientes ont été étudiés. Chaque patiente a bénéficié du même type d'anesthésie, sauf pour la FIO₂ après l'hystérotomie. Un groupe recevait 50% d'oxygène, alors que le second groupe recevait 100% d'oxygène. Malgré des PO₂

maternelles plus élevées à la naissance pour le groupe 100% O₂ (177,4 ± 42,3 mmHg vs 281,0 ± 94,2 mmHg), les PO₂ artérielles (19,3 ± 5,7 vs 18,5 ± 7,3 mmHg) et veineuses (31,1 ± 7,6 vs 33,0 ± 10,8 mmHg) dans le cordon ombilical n'étaient pas différentes. Certaines patientes se souvenaient d'événements durant la césarienne : une patiente dans le groupe 50% O₂ et quatre patientes dans le groupe 100% O₂. Cette différence n'était pas statistiquement significative. En conclusion, une augmentation de la FIO₂ maternelle dans la période entre l'hystérotomie et la naissance ne se reflète pas par une augmentation des PO₂ artérielles et veineuses foetales.

Many authors have shown that fetal arterial and venous PO₂ increase in proportion to the maternal inspired oxygen concentration and maternal PO₂ during Caesarean section.^{1,2} However, this has only been studied using constant maternal inspired oxygen concentration throughout the operation. Many institutions, including ours, use a higher maternal oxygen concentration for the period between hysterotomy and birth, which is usually less than three minutes. This study was designed to determine whether a high FIO₂ used for a short duration alters the fetal PO₂.

Methods

After approval by the Research and Ethics Committee of our institution, 20 women with normal term pregnancies undergoing elective Caesarean section were accepted into the study. Ten of the women were randomly assigned to receive constant maternal FIO₂ throughout the procedure (the 50% O₂ group), and ten were assigned to receive a higher FIO₂ at the time of hysterotomy (the 100% O₂ group). Each patient was anaesthetized using a standardized technique, including a left-lateral tilt. Preoxygenation with 100% oxygen was started at the time of the abdominal preparation and anaesthesia was induced just before the skin incision with thiopentone 4 mg · kg⁻¹ and muscle relaxation was produced with succinylcholine 1 mg · kg⁻¹. A rapid sequence induction was performed using cricoid

Key words

ANAESTHESIA: obstetrical;
MEASUREMENT TECHNIQUES: oximeters;
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pressure and the trachea was intubated. Before delivery, anaesthesia was maintained with nitrous oxide 50%, halothane 0.5% in oxygen 50% and muscle relaxation with vecuronium 0.04 to 0.05 mg · kg⁻¹. At the time of the hysterotomy, the same anaesthesia was continued in the 50% O₂ group and nitrous oxide was discontinued in the 100% O₂ group to provide 100% oxygen. After delivery and after the umbilical cord had been clamped, anaesthesia consisted of fentanyl 100–250 µg, nitrous oxide 66% in oxygen 34%. Halothane was usually discontinued but could be used at concentrations of 0.25–0.5% according to the clinical situation. The variables measured were: the time delays between preoxygenation, induction of anaesthesia, hysterotomy and birth. Arterial blood gas analyses were performed on blood from the mother and from the arterial and venous umbilical cord at birth. The neonate was evaluated using the Apgar score at one, five and ten minutes. The patients were also interviewed within three days after the Caesarean section to elicit awareness, using a standardised questionnaire³ (Appendix). Statistical analysis was performed using Student's *t* test, the Mann Whitney U test, or the Chi square when appropriate. A *P* value of <0.05 was considered significant.

Results

There were no statistical differences between the two groups with regard to demographic data. The time delays measured were also similar (Table I). Maternal arterial blood gases were similar for pH, PCO₂, and HCO₃⁻ but the PO₂ was less (177.4 ± 42.3 mmHg) in the 50% O₂ group than in the 100% O₂ group (281.0 ± 94.2 mmHg) (*P* < 0.01) (Table II). The differences in arterial and venous umbilical cord blood gases between the two groups were not statistically significant (Table III). The Apgar scores were different at one and at five minutes, but not at ten minutes (Table IV). There was no difference in the frequency of awareness between the 50% O₂ group (1/10) and the 100% O₂ group (4/10).

Discussion

Our results showed that, during Caesarean section, there was no increase in fetal arterial or venous PO₂ when the maternal FiO₂ was increased from 0.5 to 1.0 between hysterotomy and delivery, although the maternal PO₂ did increase. This is probably because the fetoplacental circulation is greatly disturbed at hysterotomy.

In 1971, Marx studied 76 patients distributed into three groups according to their inspired oxygen concentration: 28–30%, 65% or 93–97%.¹ She found that there were differences among all groups in maternal and fetal PO₂ at birth. However, the main difference between her study and ours is that in the Marx study, patients in each group

TABLE I Time intervals

	50% O ₂	100% O ₂
Preoxygenation – induction	304.9 ± 102.2	319.5 ± 116.9
Preoxygenation – hysterotomy	705.1 ± 145.5	761.9 ± 129.5
Preoxygenation – birth	786.5 ± 161.7	843.0 ± 143.1
Hysterotomy – birth	81.4 ± 25.4	81.1 ± 22.1

Mean ± S.D.

Values are given in seconds.

TABLE II Maternal blood gas analysis

	50% O ₂	100% O ₂
pH	7.41 ± 0.04	7.40 ± 0.05
PCO ₂ (mmHg)	36.3 ± 3.7	35.4 ± 5.3
PO ₂ (mmHg)	177.4 ± 42.3*	281.0 ± 94.2
HCO ₃ ⁻ (mEq · L ⁻¹)	22.5 ± 1.3	21.3 ± 2.1

Mean ± SD.

**P* < 0.01

breathed the same FiO₂ throughout the Caesarean section, while in our study, patients in each group breathed a different FiO₂ only between hysterotomy and birth. As far as the maternal groups are concerned, our results are comparable with the 65% O₂ group of Marx. Other studies also showed that fetal PO₂ increased in proportion to the maternal FiO₂, but all these studies were performed using the same FiO₂ throughout the Caesarean section².

Four out of ten patients in the 100% O₂ group had recall, compared with only one out of ten in the 50% O₂ group. This difference was not statistically significant, probably because our study involved too few patients. One study in 1969 reported a 17.3% incidence of unpleasant recall (which included unpleasant dreams) among 150 patients³ anaesthetized with nitrous oxide, up to 75% or more, in oxygen. In 1970, Moir reported two patients with recall in a group of 50 anaesthetized with nitrous oxide 70% in oxygen without halothane, and no recall in another group of 245 patients who received nitrous oxide 50% and halothane 0.5% in oxygen (although patients were not questioned specifically afterwards for recall).⁴ In 1971, Crawford investigated the incidence of awareness during general anaesthesia for "operative obstetrics" with the addition of methoxyflurane 0.1% to nitrous oxide 67% in oxygen after delivery of the infant. Part of his study concerned elective Caesarean sections and showed recall in five out of 135 patients in the control group but no recall in 121 patients in the methoxyflurane group (*P* < 0.05).⁵ Interestingly, all five patients who had recall in our study received halothane 0.5% before delivery and for variable times after delivery.

The Apgar scores, although different between the two groups at one and five minutes, did not show any clinically

TABLE III Umbilical cord blood gas analysis

	50% O ₂	100% O ₂
<i>Arterial</i>		
pH	7.32 ± 0.03	7.31 ± 0.02
PCO ₂ (mmHg)	47.3 ± 8.2	50.8 ± 6.0
PO ₂ (mmHg)	19.3 ± 5.7	18.5 ± 7.4
HCO ₃ ⁻ (mEq · L ⁻¹)	23.7 ± 3.0	25.0 ± 2.0
<i>Venous</i>		
pH	7.34 ± 0.03	7.34 ± 0.01
PCO ₂ (mmHg)	44.0 ± 6.5	43.2 ± 5.5
PO ₂ (mmHg)	31.1 ± 7.6	33.0 ± 10.8
HCO ₃ ⁻ (mEq · L ⁻¹)	23.5 ± 2.2	23.3 ± 2.3

Mean ± SD.

TABLE IV Apgar scores

	50% O ₂	100% O ₂
<i>Apgar score at</i>		
1 min	9 (8–10)	8 (3–9)*
5 min	10 (9–10)	9 (4–10)*
10 min	10 (10–10)	10 (7–10)

Mode (range).

**P* < 0.05.

significant difference and were not related to low fetal pH. Two neonates in the 100% O₂ group had low Apgar scores, which accounted for the difference. The first had Apgar scores of 3 at one minute and 9 at five minutes with umbilical venous and arterial PO₂ of 39 and 12 mmHg respectively. The second had Apgar scores of 4 at one minute, 4 at five minutes and 7 at ten minutes with umbilical cord venous and arterial PO₂ of 35 and 15 respectively. There was no explanation for these low Apgar scores. The period between hysterotomy and birth was comparable between the two groups and never exceeded three minutes, after which the incidence of fetal acidosis increases.⁶

In conclusion, our study showed that there is no advantage in using an FiO₂ of 1.0 in the period between hysterotomy and birth to try to improve fetal PO₂. Also, the removal of nitrous oxide for a short period might increase the incidence of maternal awareness.

Appendix

Questionnaire to detect awareness

- 1 What was the last thing you remember before going to sleep?
- 2 What was the next thing you were aware of?
- 3 Did you dream?
- 4 Did you feel any pain before you woke up?
- 5 When did you first feel pain?
- 6 Would you object to a similar anaesthetic again?

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