MATERNAL INSPIRED OXYGEN CONCENTRATION AND NEONATAL STATUS FOR CAESAREAN SECTION UNDER GENERAL ANAESTHESIA

Comparison of Effects of 33 % or 50 % Oxygen in Nitrous Oxide

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The conflicting requirements of adequate oxygenation and minimal drug-induced depression of the fetus at delivery, and the avoidance of intraoperative maternal awareness present a dilemma in devising an ideal general anaesthetic technique for Caesarean section. The use of an inspired anaesthetic gas mixture of 50 % nitrous oxide in oxygen [1-4], with the addition of low concentrations of volatile agents represents current practice. However, this technique has not eliminated entirely the problem of awareness during operation [5].

This study was designed to compare the biochemical and physical status of neonates born to mothers given one of two commonly used ratios of nitrous oxide and oxygen to breathe during Caesarean section under general anaesthesia.

PATIENTS AND METHODS

Women included in this study, which was approved by the Bristol and Weston DHA Ethics Committee were ASA grades I or II undergoing general anaesthesia for Caesarean section. Patients were excluded from the study if there was fetal distress requiring urgent delivery. Preparation of all patients included premedication with either ranitidine 50 mg i.v. 1 h before induction, or ranitidine 150 mg by mouth 12 h and 1 h before surgery, depending on the indication for Caesarean section. After ingesting 30 ml of sodium citrate 0.3 moliitre⁻¹ solution, the patient was transported to the operating theatre in the left lateral position. A 16-gauge i.v. cannula was inserted into a vein under local anaesthesia and Hartmann's solution 500-750 ml administered i.v. with the patient in the left wedged position. Baseline pre-induction arterial pressure and heart rate were recorded using an automatic non-invasive monitoring device. Pre-oxygenation was

SUMMARY

The relationship between maternal \(F_1O_2\) and umbilical venous \(P_{O_2}\), \(PC_{O_2}\), \(pH\) and neonatal Apgar and TSR (time to sustained respiration) scores was studied in 35 patients undergoing Caesarean section under general anaesthesia. Patients were allocated randomly to breathe an \(F_1O_2\) of either 0.5 or 0.33. Umbilical venous blood was collected at the time of delivery, and TSR and 1- and 5-min Apgar scores recorded. Mean values for umbilical venous blood were: \(P_{O_2}\) 3.9 kPa and 3.7 kPa; \(P_{C_{O_2}}\) 6.2 kPa and 6.2 kPa; \(pH\) 7.30 and 7.31 (50% and 33% groups, respectively (P > 0.05)). No differences were found between groups for 1- or 5-min Apgar scores or TSR values. It is concluded that no difference in fetal outcome or acid-base status can be detected when maternal \(F_1O_2\) is decreased from 0.5 to 0.33, and that the use of 33% oxygen in 66% nitrous oxide appears to be safe for neonates who have not suffered fetal distress before delivery.
undertaken using a Magill anaesthetic system with oxygen 8 litre min\(^{-1}\) for 5 min.

General anaesthesia was induced with a sleep dose of thiopentone 3–4 mg kg\(^{-1}\) i.v. and the trachea intubated, following the i.v. administration of suxamethonium 100 mg, while cricoid pressure was applied. Neuromuscular blockade was provided with atracurium 0.3 mg kg\(^{-1}\). Anaesthesia was maintained with nitrous oxide and 0.8% isoflurane in oxygen. The patient's lungs were ventilated with a non-rebreathing circuit, a minute volume dividing ventilator and a tidal volume of 10 ml kg\(^{-1}\) and frequency of 12 b.p.m. in order to avoid hypocapnia. Maternal arterial pressure, ECG and heart rate were monitored and measurements recorded at regular intervals.

Patients were allocated alternatively to receive oxygen and nitrous oxide in either a 50:50 ratio (group A) or a 33:67 ratio (group B). The two anaesthetic techniques were otherwise identical. The oxygen concentration of the inspired gas was measured using an oxygen analyser and the total fresh gas flow monitored with a Wright's spirometer.

At delivery of the infant, a segment of cord was double cross clamped immediately and blood samples obtained from the isolated vein into heparinized syringes. The samples were placed on ice and analysed within 30 min using an automated machine that was calibrated regularly. Umbilical vein oxygen tension, carbon dioxide tension and pH were measured.

The following data relevant to neonatal outcome were collected: presentation of the infant at birth, induction to delivery interval (min), uterine incision to delivery interval (s) and time to sustained ventilation (s). Neonatal Apgar scores at 1 and 5 min were awarded on a scale of 1–8 (excluding colour) by paediatricians who were unaware of the maternal inspired oxygen concentration.

At the postoperative visit, recollection of intraoperative dreams and the possibility of awareness were sought.

Student's \(t\) test was used to compare the two groups for data that were distributed normally (umbilical vein \(\text{Po}_2\), \(\text{PCO}_2\) and pH). For time to spontaneous ventilation, induction to delivery interval (I–D) and uterine incision to delivery interval (U–D) interval, the Mann–Whitney \(U\) test was used. Apgar scores were compared using a Chi-squared test with Yates' correction.

### RESULTS

Thirty-five patients were included in the study: 16 in group A (50% oxygen) and 19 in group B (33% oxygen). Indications for Caesarean section

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**Table I. Comparison of outcome variables for 50% and 33% oxygen concentration groups**

| & Group A (\(n = 16\)) & Group B (\(n = 19\)) & Statistics & 95% CI for diff. |
|---|---|---|---|---|
| Umbilical vein | | | | |
| Mean \(\text{Po}_2\) (kPa) | 3.9 | 3.7 | \(t = 0.6, P = 0.5\) | 1.5 | -3.3–6.1 |
| Mean \(\text{PCO}_2\) (kPa) | 6.2 | 6.2 | \(t = -0.1, P = 0.9\) | -0.2 | -5.3–4.8 |
| Mean pH | 7.30 | 7.31 | \(t = -0.9, P = 0.4\) | -0.01 | -0.05–2.02 |
| Time to spontaneous ventilation (s) | | | | |
| Median | 12.5 | 10.0 | \(\nu = 2.09, P = 0.5\) | | 5–90 |
| Range | 5–180 | 2-240 | | | |
| Apgar (minus colour): No. with scores 7 or 8 | | | | |
| 1 min | 7 (43%) | 9 (47%) | \(\chi^2 = 0.02, P = 0.9\) | | -4% | 37-29% |
| 5 min | 16 (100%) | 17 (89%) | | | |
| Induction–Delivery interval (min) | | | | |
| Median | 7.0 | 8.0 | \(\nu = 274, P = 0.7\) | | -1.0 | -3.0–1.7 |
| Range | 5–12 | 2–20 | | | |
| Uterine incision–delivery interval (s) | | | | |
| Median | 80.0 | 87.0 | \(\nu = 270, P = 0.6\) | | -7 | -45–30 |
| Range | 15–240 | 30–480 | | | |
included breech presentation, previous Caesarean section, cephalo-pelvic disproportion and failure to progress in labour.

There were no statistically significant differences between the two groups with regard to outcome variables (table I). The condition of the neonates at birth was generally good. The two neonates in group B with 5-min Apgar scores less than 7 both had scores of 6. In the first infant the individual umbilical vein $P_{O_2}$ was 3.5 kPa, but the I–D time was 120 s—a time associated with peak circulating concentrations of thiopentone. In the second infant no cause for the score to be 6/8 was identifiable.

Factors likely to influence neonatal outcome, other than the choice of anaesthetic technique, were noted. By chance, all of the abnormal presentations at delivery occurred in the group which received 33 % oxygen: all neonates in group A were delivered head first and there were four breech presentations and one transverse lie in group B. No apparent differences were demonstrated between the condition of the neonates born to each group. There was no episode of hypotension in any patient defined as a systolic arterial pressure of less than 100 mm Hg or a reduction in systolic pressure of 30 mm Hg during the induction–delivery interval. At post-operative interview, some mothers reported pleasant dreams, which bore no relationship to the anaesthetic or surgery. There were no reports of awareness under anaesthesia.

**DISCUSSION**

The techniques of general anaesthesia for Caesarean section are designed to optimize neonatal condition at delivery, produce maternal cardiovascular stability and prevent maternal pulmonary aspiration. They may result in an appreciable and probably under-reported incidence of intraoperative awareness because of inadequate depth of anaesthesia. This problem has been discussed widely [6–15]. Some have suggested that a brief and mild degree of neonatal sedation following delivery, caused by the use of higher concentrations of volatile agents, represents a minor disadvantage for reducing the incidence of intraoperative awareness [5, 16]. However, this approach carries the increased risk of inducing maternal hypotension and inhibiting uterine contraction after delivery, resulting in haemorrhage [3].

In clinically appropriate concentrations, nitrous oxide does not inhibit uterine contraction, and higher concentrations are associated with deeper planes of anaesthesia, particularly in pregnancy [17]. Furthermore, increasing the $F_{I_{N_2O}}$ increases the rate of uptake of volatile anaesthetic agents by the second gas affects, thereby hastening the onset of surgical anaesthesia.

A number of studies have been undertaken in the past to investigate the influence of different $F_{I_{O_2}}$ values on neonatal outcome. However, none has been undertaken to compare an $F_{I_{O_2}}$ of 0.33 with 0.5.

Our data suggest that there is no difference in neonatal outcome if the maternal $F_{I_{O_2}}$ is decreased from 0.5 to 0.33. Our results differ from similar work in a number of important respects. The most widely quoted publication on varying maternal inspired oxygen concentrations and neonatal condition at delivery by Caesarean section is by Marx and Mateo [4]. They reported that an increased maternal $F_{I_{O_2}}$ was associated with increased umbilical venous oxygen tensions. The $F_{I_{O_2}}$ favoured most was 0.6. They reported that a higher umbilical venous oxygen tension was associated with improved clinical condition of the infant at 1 min. However, no difference in neonatal outcome persisted for more than 5 min after delivery, suggesting that any differences at 1 min resulted from temporary sedation by rapidly excreted anaesthetic agents.

The study by Rorke [1] also failed to present biochemical data as evidence that the low Apgar scores obtained in the low (33 %) oxygen group neonates resulted from asphyxia. Despite the long I–D intervals (45.9–52.3 min) and the resultant increase in nitrous oxide received by the neonate that this would induce, the physical findings of apnoea, cyanosis, bradycardia and hypotonus implicit in an Apgar score of 3 do not reflect the known pharmacological properties of nitrous oxide in the neonate.

There is no evidence that the umbilical venous $P_{O_2}$ produced with a maternal $F_{I_{O_2}}$ of less than 0.5 is pathological and not tolerated easily by the neonate. In all the studies in which umbilical venous $P_{O_2}$ has been measured, the values presented are in excess of those obtained at normal vertex delivery. In the low oxygen group (28 %) in the study by Marx and Mateo [4], the umbilical vein $P_{O_2}$ of the neonates was 3.7 ± 0.3 kPa, similar to that found in normal vertex delivery. Mean umbilical vein oxygen tensions at
normal vertex vaginal delivery reported in various studies lie in the range 2.8–3.9 kPa [21]. Analysis of the umbilical vein pH in all groups failed to demonstrate evidence of fetal asphyxia in any neonate, irrespective of the maternal $F_{1O_2}$ [1].

It has been suggested that maintaining a high maternal $F_{1O_2}$ ensures adequate oxygen reserves in the neonate after delivery [4]. However, values of maternal $F_{1O_2}$ greater than 0.5 are required if significant increases in umbilical vein $P_{O_2}$ are needed. It is our view that the theoretical advantage of achieving neonatal oxygen tensions greater than those found at normal vertex vaginal delivery is of doubtful value, particularly if this is at the expense of adequate maternal anaesthesia.

Induction-delivery intervals of 7–8 min imply that equilibration between inspired concentrations of nitrous oxide and volatile agents does not occur [18]. Materno-fetal equilibration of nitrous oxide takes 35 min or more after an initial rapid uptake by the fetus [18, 19]. Nitrous oxide taken up by the fetus in utero is excreted rapidly within a few breaths by the neonate [20].

Although Marx and Mateo used prophylactic uterine displacement to prevent aortocaval compression and obtained I-D and U-D intervals similar to those of the present study, their results cannot be compared directly with ours. Their choice of volatile anaesthetic agents differed for each oxygen group, thus introducing a variable other than $F_{1O_2}$. Thus there is a possibility that the volatile anaesthetic agent may have a more significant effect on the neonate and utero-placental perfusion than was realized. These authors also reported that significantly higher Apgar scores were obtained in neonates born to hyperoxygenated mothers. This difference was based on a single 1-min score. Comparison of the first of two Apgar scores with a second is a more useful indicator of neonatal well-being than a single score. The use of two scores at a 5-min interval enables temporary sedation, evident within 1–2 min of birth and induced by rapidly excreted inhalation anaesthetic agents, to be distinguished from the consequences of intrauterine asphyxia. Oliver, Demis and Bates [22] found no differences after 5 min from birth between the neonates whose mothers had received oxygen continuously before delivery and those that had not.

Other studies [1, 2] have supported the finding of a positive correlation between maternal inspired oxygen concentrations and umbilical oxygen tensions, although the anaesthetic techniques used differed considerably from current practice. No lateral tilt or wedge was used by these investigators. Moir [3] compared the effects of two concentrations of nitrous oxide, but only one group received a volatile agent. Rorke [1] and his fellow authors were also unaware of the significance of prolonged I-D and U-D intervals. The latter value extended to 45 min or more in some patients.

Ramanathan and colleagues [23] have demonstrated that maternal hyperoxia increases umbilical venous and arterial $P_{O_2}$ values and acid-base status during Caesarean section under extradural anaesthesia. These authors suggested that improvement in the neonate occurred because the umbilical venous $P_{O_2}$ was increased, although they were unable to demonstrate any significant difference in 1- and 5-min Apgar scores. Both the umbilical venous and umbilical arterial values reported were equal or in excess of the umbilical venous $P_{O_2}$ found at normal vertex delivery, even with an $F_{1O_2}$ of 0.21. It is a matter of debate if this represents an improvement.

In conclusion, our results show that, during general anaesthesia for Caesarean section, reduction of the $F_{1O_2}$ from 50% to 33% in nitrous oxide with 0.8% isoflurane is not associated with a clinically or statistically significant difference in the biochemical or clinical status of the neonates born within approximately 7–8 min of induction of anaesthesia. It is our view that an increased concentration of nitrous oxide can be used without detriment to the neonate in the absence of severe fetal distress. Although the study was not designed to investigate the incidence of maternal awareness during general anaesthesia for Caesarean section, theoretically this technique should reduce the incidence further.

REFERENCES


