Effect of Supplementing Oxygen with Positive end Expiratory Pressure During Elective Caesarean Section under Spinal Anaesthesia on Foetus

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ABSTRACT

**Background:** It is known fact that pre-oxygenation with positive end-expiratory pressure (PEEP) improves the Partial pressure of oxygen (PO$_2$). In this regard not many studies have been done in pregnant women to know its effect on foetus. In this randomised double blind controlled study, we analysed effect of pre-oxygenation with PEEP during caesarean section on foetal umbilical venous PO$_2$.

**Patients & Methods:** 40 term pregnant women, ASA I or II, undergoing elective Caesarean section under spinal anaesthesia were randomly divided into PEEP and Non-PEEP groups of 20 each. PEEP group received oxygen flow of 6 L/minute with PEEP of 5 cmH$_2$O using a modified Mapleson A circuit with fixed unidirectional PEEP valve at the expiratory port during pre-oxygenation and Non PEEP group received same fresh gas flow of oxygen using same breathing circuit without PEEP. Maternal arterial blood samples were collected before applying PEEP and at the end of 5 minutes of facemask application for oxygen analysis. Immediately after baby was delivered umbilical venous samples were taken for blood gas analysis.

**Results:** Both groups were comparable in terms of maternal baseline oxygen saturation (Spo$_2$) and base line Po$_2$. After 5 minutes PO$_2$ was higher in PEEP Group than non PEEP group (491.65 + 49.96 vs. 452.08 + 77.61). Umbilical venous Po$_2$ in PEEP group was higher than non PEEP group (34.22 + 6.50 vs. 28.29 + 6.10 mm of Hg).

**Conclusion:** Application of PEEP during pre-oxygenation for spinal anaesthesia can increase foetal umbilical venous PO$_2$.

**KEYWORDS:** Pre-oxygenation, Positive end-expiratory pressure, Caesarean section, Foetus.

It is common practice to supplement oxygen to parturient before caesarean section by either nasal prongs or facemask. The effect of the positive end expiratory pressure (PEEP) on improving partial pressure of oxygen (PO$_2$) is well established. However, not many similar studies have been done in pregnant women in this regard and also to know its effect on foetus. In this randomised double blind controlled study, we analysed effect of the application of PEEP during pre-oxygenation on the maternal PO$_2$ and umbilical venous PO$_2$ in foetus.

**PATIENTS AND METHODS**

The prospective randomised controlled was commenced after obtaining approval from hospital ethical committee. Written informed consent was taken from all the patients.

40 term pregnant women, ASA I or II, undergoing elective lower segment Caesarean section under spinal anaesthesia were randomly divided in to PEEP and Non-PEEP groups of 20 each.

Parturients with cardiopulmonary diseases, pre-eclampsia, anaemia, haemoglobinopathies, history of smoking, ante-partum haemorrhage, multiple gestations, antenatally diagnosed placental anomalies, hyper maturity of placenta, with foetal distress and any condition which likely to compromise foetal oxygenation were excluded from the study.

All patients kept 8 hours Pre-operative fasting. Observer 1 (Resident Anaesthesiologist) premedicated Parturient with tab ranitidine 150mg and tab. metoclopramide 10mg orally 2 hr before surgery. Parturients were randomly divided into either of the two groups by drawing shuffled sealed lots and were shifted in left lateral position to the operating room and standard monitors were connected. Baseline vitals were recorded. Intravenous line was secured on non-dominant hand and all patients were preloaded with 15ml kg$^{-1}$ body weight lactated Ringer’s solution. An arterial line was secured in radial artery of non-dominant hand with 20 gauge cannula and maternal arterial blood sample was taken for baseline blood gas analysis. Spinal anaesthesia was performed in left lateral position with 2 ml of 0.5% bupivacaine (heavy) by observer 2 (Consultant Anaesthesiologist). We aimed for a sensory block of T4 -T5 dermatome level. Immediately after giving the spinal anaesthesia patients were positioned supine with 15° lateral
tilt of operating table. Hypotension (more than 20% decrease in mean arterial blood pressure from the baseline) was managed with boluses of ringer's lactate solution (crystalloid) followed by boluses of 6mg ephedrine as required and the intervention details were recorded.

After positioning supine, PEEP group received oxygen flow of 6 L/minute with 5 cmH\textsubscript{2}O PEEP using a modified Mapleson's A circuit with a fixed unidirectional PEEP valve (Armstrong medical\textsuperscript{TM}) (figure 1) at the expiratory port during pre-oxygenation and Non PEEP group received the same fresh gas flow of oxygen without PEEP using the same breathing circuit. Observer 2 applied facemask and maintained it tight sealing during the pre-oxygenation till baby delivery. All patients breathed oxygen via mask at normal tidal volume and rate during pre-oxygenation with closed mouth.

Another maternal arterial blood sample was collected at the end of 5 minutes of facemask application for Po\textsubscript{2} analysis.

Inability to maintain tight mask fit at any time, inadequate spinal anaesthesia and further administration of general anaesthesia were excluded from the study.

The timings of spinal anaesthesia, pre-oxygenation, uterine incision, baby delivery and intervals between these were noted using a stopwatch.

Immediately after delivery of the baby obstetrician triple clamped the umbilical cord with an extra cord clamp at 10 centimetres proximally towards the placental side. The umbilical cord was cut between the two distal clamps. Umbilical venous samples were taken for blood gas analysis between the two clamps by obstetrician.

Observer 3 (Resident Paediatrician) who was blinded regarding the pre-oxygenation sequence assessed the newborn's Apgar score at 1 and 5 minutes and recorded the birth weight.

After the delivery, the mothers in PEEP group were made to breathe 100% oxygen via the same circuit with out PEEP for 3 minutes and those in Non-PEEP group were made to breathe from the same circuit with 5 cm H\textsubscript{2}O PEEP for 3 minutes to assess the compliance of the mothers to simple mask holding and mask holding with application of PEEP. Compliance to mask holding and compliance to PEEP application were recorded separately.

Maternal and umbilical cord blood samples were analysed using Roche omni C\textsuperscript{TM} blood gas analyser immediately after sampling.

Independent sample t-test was used in analysing the demographic data, comparison of time intervals, maternal and umbilical blood gas analysis data, birth weight of newborn. Pearson Chi-square test was used in analysing the comparison of crystalloid bolus requirement. Fisher's Exact test was used in the comparison of requirement of ephedrine and atropine as well as analysing the maternal compliance to PEEP application and conventional mask holding. Mann Whitney U test was used in analysing the Apgar scores.

Data was expressed in mean mean ± standard deviation and median as necessary and p< 0.05 is considered significant. (Data was analysed using SPSS for Windows release 11.0.0. (19 Sep 2001)).

RESULTS

Maternal Data
40 term pregnant women of ASA physical status I and II were analysed in the study. All parturients of both groups were comparable in terms of age, weight, height, body mass index, parity and gestational age. Table 1 shows analysis of spinal anaesthesia to baby delivery interval, uterine incision to baby delivery interval, start of pre-oxygenation to baby delivery interval. There was no significant difference between groups of these intervals.

There was no significant difference in requirement of crystalloid and ephedrine boluses for treating hypotension between the groups.

Both groups were comparable in terms of maternal baseline oxygen saturation (SpO\textsubscript{2}) and base line Po\textsubscript{2}. After 5 minutes Po\textsubscript{2} in PEEP Group was higher than non PEEP group (491.65±49.96 vs. 452.08±77.61) but it was statistically not significant as shown in table 2. The minimum and maximum values for maternal arterial blood oxygen tension at 5 minutes of pre-oxygenation in PEEP group were 358
and 593 mmHg respectively where as those for Non-PEEP group were 289 and 548 mmHg.

We analysed data regarding the need of reassurance for the mother while undergoing either of the techniques as shown in figure 3. It was found that there was no statistically significant difference between either techniques regarding patient compliance.

**Fetal Data**

Umbilical venous oxygen saturation in PEEP group was 57.69±14.39% where as in non PEEP group it was 46.36±14.99 and umbilical venous oxygen tension in PEEP group was 34.22±6.50 mm of Hg where as in non PEEP group it was 28.29±6.10 mm of Hg. The differences between the groups were statistically significant as shown in table 3. (One umbilical blood gas result excluded because of the technical error during sample analysis).

| Variable                      | Group       | N  | Mean ± Std. Deviation | Significance |
|-------------------------------|-------------|----|-----------------------|--------------|
| Umbilical-venous pH           | PEEP        | 20 | 7.32 ± 0.04           | p=0.468      |
|                               | Non-PEEP    | 19 | 7.30 ± 0.08           |              |
| Umbilical venous saturation   | PEEP        | 20 | 57.69 ± 14.39         | p=0.021      |
|                               | Non-PEEP    | 19 | 46.36 ± 14.99         |              |
| SvO2 (%)                      | PEEP        | 20 | 34.22 ± 6.50          | p=0.006      |
|                               | Non-PEEP    | 19 | 28.29 ± 6.10          |              |
| Umbilical venous oxygen tension | PEEP    | 20 | -2.74 ± 1.60          | p=0.159      |
|                               | Non-PEEP    | 19 | -3.73 ± 2.63          |              |

Birth weight, Apgar score at 1 and 5 minutes of the newborns were comparable in both groups as shown in figure 3 and 4.

| Variable                      | Group       | N  | Mean ± Std. Deviation | Significance |
|-------------------------------|-------------|----|-----------------------|--------------|
| Maternal baseline SpO2 (%)    | PEEP        | 20 | 97.30 ± 1.72          | p=0.293      |
|                               | Non-PEEP    | 20 | 97.80 ± 1.20          |              |
| Maternal SpO2 at 5 minutes (%)| PEEP        | 20 | 99.85 ± 0.366         | p=0.643      |
|                               | Non-PEEP    | 20 | 99.90 ± 0.308         |              |
| Maternal baseline PaO2 (mm Hg)| PEEP        | 20 | 103.61 ± 9.12         | p=0.928      |
|                               | Non-PEEP    | 20 | 103.32 ± 10.72        |              |
| Maternal PaO2 (mm Hg) at 5     | PEEP        | 20 | 491.65 ± 49.96        | p=0.063      |
|                               | Non-PEEP    | 20 | 452.08 ± 77.61        |              |

- Independent sample t-test used
- p-value =0.05 considered statistically significant
DISCUSSION
Studies have established the fact that by increasing maternal PaO₂, foetal PO₂ can be increased as oxygen diffuses across the placenta by pressure gradient. Study by Ramanathan S et al regarding the optimum FiO₂ for Caesarean section under epidural anaesthesia showed a linear increase in foetal oxygenation with the appraisal of maternal PaO₂. Later, the existence of such an increase and its merits and demerits were questioned by many other studies.

In our study, we evaluated whether the application of PEEP improves maternal and foetal PO₂ in comparison with a control of Non-PEEP group during spinal anaesthesia. We started supplementing 100% oxygen after established spinal anaesthesia and this may not exactly replicate a pre-oxygenation before general anaesthesia. This is because in our study, the spinal anaesthesia was aimed at T4 -T5 dermatomal level, which might interfere with the normal breathing.

Shelley and Gutsche states that 6 min of oxygen inhalation is required for equilibration of foetal oxygen levels after the change in maternal values. Myers et al studying Rhesus monkeys showed that maternal administration of oxygen increases foetal tissue PO₂ beginning within 60 seconds and equilibrating with 3 minutes. Longo and Power constructed a systems model of placental O₂ transfer and suggest that foetal oxygen levels completely respond within 75 seconds to changes in umbilical oxygen supply. Norris et al have shown that in the parturient both 3 min of oxygen breathing and the four-deep breath, 30-s technique are adequate for pre-oxygenation prior to rapid sequence induction of general endotracheal anaesthesia for Caesarean section. Considering those factors we decided to take maternal blood samples after 5 minutes of pre-oxygenation for blood gas analysis. Maternal PaO₂ in PEEP group after 5 minutes of pre-oxygenation was slightly more than Non-PEEP group (491.65±49.96 versus 452.08±77.6). Even though the values were not showing a significant difference statistically, a difference of 39 mmHg is seen between the groups which can be of clinical importance in a difficult intubation situation.

The umbilical venous PO₂ in PEEP group was found to be significantly higher than Non-PEEP group (34.22±6.50 versus 28.29±6.10). This showed that pre-oxygenating with PEEP increases the umbilical venous PO₂. There were no findings of foetal distress and all babies were having a normal Apgar score. The umbilical venous blood pH also was comparable between both groups. Question may arise as when there is no significant difference in the maternal PO₂ how can there be a significant difference in the umbilical venous PO₂? A probable explanation for this is as the mother is breathing 100% O₂ there could have been formation of absorption atelectasis which was prevented by applying PEEP. So in our patients the elevated PaO₂ at 5 minutes of oxygen may not have sustained in Non-PEEP group because of possible atelectasis formation. But such an existence of atelectasis is not analysed directly in our study.

We consider that the compliance of the mother to the pre-oxygenation techniques will be a significant confounding factor for the efficacy of the techniques. We collected data regarding the need of reassurance for the mother for either of the techniques. An interchanging of the techniques of oxygen application was conducted immediately after the delivery. Our study showed that there was a clinically significant increase in the number of mothers needed reassurance with PEEP application when compared with Non-PEEP group. We consider that non-compliance can be a factor which needs attention in subjecting an already distressed mother to the PEEP application. In such a situation one has to weigh the risks and benefits of the PEEP, individualising to the situation.

In summary our study showed that application of PEEP during pre-oxygenation for spinal anaesthesia can increase maternal arterial PO₂ and foetal umbilical venous PO₂ when compared to Non-PEEP Group and is tolerated by majority of the individuals studied.

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