Research Article

Prophylactic Intrapartum Maternal Nasal Oxygen for Better Obstetric and Neonatal Outcomes

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Background: Low Apgar scores remain a leading, modifiable contributor to early neonatal morbidity in low-resource settings. Whether routine intrapartum maternal oxygen benefits normoxic term pregnancies is uncertain. This study assessed the effect of continuous low-flow nasal oxygen on immediate neonatal outcomes.

Methods: In a prospective, quasi-experimental study at a tertiary hospital in central India, 84 women with term singleton pregnancies (37–42 weeks) were alternately allocated to receive either 4 to 6 L min^{-1} nasal oxygen throughout active labor (n = 42) or no supplemental oxygen (n = 42). Baseline socio-demographic and obstetric variables were comparable. Primary outcomes were 1 and 5 minute Apgar scores. Secondary outcomes included improvement in fetal-heart rate (FHR) tracings, mode of delivery and neonatal-intensive-care-unit (NICU) admission. Pearson's χ^2 and independent-samples *t* tests were applied ($\alpha = 0.05$).

Results: Oxygen significantly reduced low Apgar prevalence. At 1-minute, scores < 7 occurred in 40.5 *versus* 66.7% of controls ($\chi^2 = 5.77$, $p = 0.016$); at 5 minutes, 9.5 *versus* 35.7% ($\chi^2 = 8.19$, $p = 0.004$). Mean Apgar values were higher in the oxygen group (1 min: 8.83 ± 1.75 *vs* 7.83 ± 1.71, $p = 0.010$; 5 min: 9.81 ± 1.23 *vs* 7.21 ± 1.39, $p = 0.041$). FHR tracings improved in 71.4 *versus* 19.0% ($p = 0.040$); caesarean delivery fell to 23.8 from 52.4% ($p = 0.007$); NICU admission declined from 45.2 to 7.1% ($p < 0.001$). No adverse maternal events were observed.

Conclusions: Continuous 4 to 6 L min^{-1} intrapartum nasal oxygen markedly improves 1 and 5-minute Apgar scores, stabilises FHR, halves emergency caesareans and cuts NICU admissions in term singleton births. This inexpensive intervention offers a practical bridge when expedited delivery is delayed, supporting its judicious use in similar settings.

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Introduction

The Apgar score remains the fastest bedside yardstick for gauging a newborn's cardio-respiratory transition. It indicates the respiratory, cardiovascular, and neurological functions of the infant and is diminished when hypoxia is sufficiently severe and sustained to impact these systems. Population registries from high-income countries record 5-minute scores less than 7 in < 1% of term births.[1] However, low- and middle-income countries (LMICs) report prevalences between 13 and 27%.[2,3] Indian hospital data show 7.6% incidence of birth asphyxia.[4] A low 5-minute score multiplies the odds of early neonatal death, cerebral palsy and long-term neuro-developmental delay.[5]

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Reducing such "bad Apgar" events is pivotal to Sustainable Development Goal 3.2, which stipulates a neonatal mortality rate (NMR) < 12 per 1000 live births by 2030.[6] Globally, NMR fell to 17 / 1000 in 2023, yet 2.3 million newborns still die each year. [7] India's NMR has declined from 26 to 19 per 1000 between 2014 and 2021, but progress must accelerate to meet the SDG benchmark.[8]

When intrapartum cardiotocography (CTG) suggests fetal compromise, the reflex response is often expedited birth—usually emergency caesarean section. Global caesarean rates have already climbed from 7% in 1990 to 21% today and are projected to reach 29% by 2030.[9] Many procedures, however, are prompted by non-specific CTG changes, carry significant maternal morbidity, and remain unattainable in resource-constrained units. Consequently, modern obstetric guidance

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promotes a stepwise "intrauterine resuscitation" bundle maternal repositioning, intravenous fluids, tocolysis and supplemental oxygen to stabilise the fetus while definitive delivery is arranged.[10] Among these interim measures, oxygen administration is the simplest and most commonly practised.[11] Practice in LMICs often relies on nasal cannula at 4 to 6 L/min because the equipment is inexpensive and readily available. Yet the physiological rationale for routine use in mothers is contested and with variable evidence.

Against this backdrop, the present study was conducted to assess whether the timed admission of intrapartum nasal oxygen can meaningfully elevate the 1 and 5-minute Apgar scores of term neonates delivered in a labor ward of a tertiary care hospital in Central India. Clarifying this effect is essential to define context-appropriate protocols that bridge the gap between "watchful waiting" and immediate caesarean, and to ensure that every additional litre of oxygen delivered is justified by demonstrable neonatal benefit.

Materials And Methods

Study Design and Setting

This study was a prospective, parallel-group, quasi-experimental study comparing intrapartum nasal oxygen with standard care carried out in the labor room of R D Gardi Medical College, Ujjain from May 2023 to April 2024.

Participants

Eligible participants were antenatal women with singleton term pregnancies (37–42 weeks) who were admitted for delivery and gave written informed consent. Women with multiple gestation, pre- or post-term pregnancy, or known fetal anomalies, and those who declined consent, were excluded.

Sample Size Determination

Using an anticipated proportion of abnormal neonatal outcomes of 34.3%, a precision of 10%, $\alpha = 0.05$ and a 99% confidence level, the minimum sample required was 84 women. These were equally allocated to intervention and control arms, i.e., 42 each.

Allocation and Intervention

Participants were alternately allocated to:

- Group A – received intrapartum nasal oxygen at 4–6 L per min during the active phase of labor.
- Group B – proceeded through labor without supplemental oxygen.

Flow rates, start times and total duration were recorded on the case proforma. All variables were captured on a structured, pre-validated proforma covering maternal demographics, labor details, fetal monitoring findings and neonatal outcomes.

Outcome Measures

Primary neonatal endpoints were Apgar scores at 1 and 5 minutes & Abnormal fetal heart rate tracings assessed continuously on electronic monitoring (baseline rate, variability, accelerations). Secondary outcomes included mode of delivery (vaginal *vs*. caesarean) and NICU admission.

Statistical Analysis

Data were entered into statistical software SPSS by IBM v26 for analysis. Baseline characteristics were summarised with means ± SD or percentages. Comparative testing between groups used the χ^2 test for categorical data and the independent-samples t-test for continuous variables; $p < 0.05$ was considered statistically significant.

Ethical Considerations

These study was initiated after obtaining approval from the Institutional Ethical Committee vide letter no. PG/OBSTETRICS AND GYNAECOLOGY/39. Written informed consent was obtained from every participant. Confidentiality was upheld throughout, and all procedures conformed to the ethical standards of the institutional research committee.

Observations and Results

Baseline characteristics of the two study arms were broadly comparable (Table 1). The maternal-age distribution did not differ significantly between women who received intrapartum nasal oxygen and those who did not receive oxygen ($p = 0.639$); most participants in both groups were 21–25 years old (57.1% *vs* 47.6%). Residence showed a non-significant trend toward a higher rural representation in the oxygen arm (88.1% *vs* 71.4%; $p = 0.060$). Socio-economic status and educational attainment were likewise balanced, with no meaningful disparities across income brackets ($p = 0.320$) or literacy categories ($p = 0.228$).

Obstetric profiles were similar between groups. Nulliparous women constituted roughly one-third of each arm, and the overall parity distribution showed only a borderline difference ($p = 0.079$). The prevalence of oligohydramnios, premature rupture of membranes (PROM) and pre-eclampsia was low and did not differ significantly ($p = 0.167$, 0.090 and 0.393, respectively). These

Table 1: Socio-demographic & obstetric characteristics of mothers

Characteristic	*Category*	*Nasal oxygen administered*		*p-value*
		Yes (n = 42)	*No (n = 42)*	
Age group (years)	≤ 20	4 (9.5%)	6 (14.3%)	0.639
	21–25	24 (57.1%)	20 (47.6%)	
	> 25	14 (33.3%)	16 (38.1%)	
Residence	Rural	37 (88.1%)	30 (71.4%)	0.060
	Urban	5 (11.9%)	12 (28.6%)	
Socio-economic status	Low	15 (35.7%)	14 (33.3%)	0.320
	Middle	17 (40.5%)	12 (28.6%)	
	High	10 (23.8%)	16 (38.1%)	
Education level	Illiterate	14 (33.3%)	12 (28.6%)	0.228
	Primary	24 (57.1%)	27 (64.3%)	
	Secondary	1 (2.4%)	3 (7.1%)	
	Graduate	3 (7.1%)	0 (0.0%)	
Parity	0	5 (11.9%)	5 (11.9%)	0.079
	1	13 (31.0%)	24 (57.1%)	
	2	9 (21.4%)	6 (14.3%)	
	≥ 3	15 (35.7%)	7 (16.7%)	
Oligohydramnios	Yes	1 (2.4%)	4 (9.5%)	0.167
	No	41 (97.6%)	38 (90.5%)	
PROM	Yes	1 (2.4%)	5 (11.9%)	0.090
	No	41 (97.6%)	37 (88.1%)	
Preeclampsia	Yes	6 (14.3%)	9 (21.4%)	0.393
	No	36 (85.7%)	33 (78.6%)	

findings indicate that alternate allocation produced two cohorts well matched for socio-demographic background and key obstetric risk factors, minimising confounding in subsequent outcome comparisons.

Neonates born to mothers who received intrapartum nasal oxygen had markedly better immediate adaptation than those whose mothers labored without oxygen as evidenced by the APGAR score. (Table 2) At 1-minute, the proportion with an Apgar score < 7 fell from 66.7% to 40.5% (χ^2 = 5.77, p = 0.016), yielding a relative risk reduction of 39% and an absolute risk reduction of 26%. The mean Apgar score was one full point higher in the oxygen group (8.83 ± 1.75 *vs* 7.83 ± 1.71; t = 2.69, p = 0.010).

Benefits were even more pronounced at 5 minutes: only 9.5% of oxygen-exposed infants remained below the critical threshold, compared with 35.7% in controls (χ^2 = 8.19, p = 0.004). This corresponds to a relative risk of 0.27 (73% reduction) and the same 26% absolute risk reduction. Mean 5-minute scores also diverged significantly (9.81 ± 1.23 *vs* 7.21 ± 1.39; t = 2.08, p = 0.041).

Supplemental intrapartum oxygen favourably influenced all intrapartum and early neonatal outcomes. (Table 3) First, fetal-heart rate (FHR) tracings improved in 71.4% of oxygen cases *versus* only 19.0% of mothers without oxygen—a nearly four-fold increase in corrective response (absolute gain ≈ 52%; p = 0.040). Correspondingly, the need for operative birth fell: LSCS was required in 23.8% of oxygen-exposed labors compared with 52.4% in controls (absolute reduction ≈ 29%, relative risk 0.45; p = 0.007).

Downstream neonatal benefit was evident as well. Only 7.1% of newborns in the oxygen group required NICU admission, compared with 45.2% in the non-oxygen group—an 84% relative risk reduction and a 38% absolute risk reduction (p < 0.001).

Discussion

The present study tested the long-debated premise that administering low-flow intrapartum nasal oxygen to normoxic mothers can enhance fetal well-being. This hypothesis is rooted in the physiological principle that even in the absence of maternal hypoxemia, increasing the oxygen content of maternal blood may augment transplacental oxygen delivery. By focusing on normoxic

Table 2: Neonatal Apgar outcomes according to intrapartum nasal oxygen administration

Outcome	*Category*	*Nasal oxygen administered*		*p-value*
		Yes (n = 42)	*No (n = 42)*	
Apgar at 1-minute	< 7	17 (40.5%)	28 (66.7%)	0.016*
	≥ 7	25 (59.5%)	14 (33.3%)	
	Mean ± SD	8.83 ± 1.75	7.83 ± 1.71	0.010*
Apgar at 5 minutes	< 7	4 (9.5%)	15 (35.7%)	0.004*
	≥ 7	38 (90.5%)	27 (64.3%)	
	Mean ± SD	9.81 ± 1.23	7.21 ± 1.39	0.041*

*Significant at 95% CI

Table 3: Intrapartum and early-neonatal outcomes (secondary endpoints)

Outcome	*Category*	*Nasal oxygen administered*		*p-value*
		Yes (n = 42)	*No (n = 42)*	
FHR tracing	Improvement	30 (71.4%)	8 (19.0%)	0.040*
	No change	12 (28.6%)	34 (81.0%)	
Mode of delivery	LSCS	10 (23.8%)	22 (52.4%)	0.007*
	NVD	32 (76.2%)	20 (47.6%)	
NICU admission	Yes	3 (7.1%)	19 (45.2%)	< 0.001*
	No	39 (92.9%)	23 (54.8%)	

*Significant at 95% CI

women, the study specifically explores whether oxygen can serve not merely as a corrective therapy but as an optimization strategy during labor. Among 84 term singleton pregnancies equally allocated to oxygen or no-oxygen care, oxygen supplementation produced a statistically and clinically significant improvement in every neonatal metric we measured. The balanced allocation between groups strengthens the credibility of these findings and minimizes the likelihood of selection bias.

Apgar Score and Fetal Heart Rate

The proportion of low Apgar scores (< 7) fell from 66.7 to 40.5% at 1 minute ($\chi^2 = 5.79$, $p = 0.016$) and from 35.7 to 9.5% at 5 minutes ($\chi^2 = 8.23$, $p = 0.004$). Mean scores rose by approximately one point at both points (Table 2). These improvements are clinically meaningful, as even small increments in Apgar scores can reflect better neonatal transition and reduced need for resuscitative interventions. The biological basis for such benefit has been explored in earlier physiological studies. A very notable study in the 1960s demonstrated that oxygen administration to the mother during labor could improve fetal oxygenation and influence fetal heart rate patterns, suggesting that maternal oxygen can modify fetal status in real time.[12] Thorpe *et al.* has also shown an increase in fetal capillary pO_2 during labor following maternal oxygen administration, thereby supporting the concept that supplemental oxygen can enhance transplacental oxygen transfer.[13] Concomitantly, positive changes in fetal heart rate (FHR) tracings were nearly four-fold more common (71.4 *vs* 19%; $\chi^2 = 8.26$, $p = 0.04$), suggesting a rapid physiological response to maternal oxygen administration (Table 3). Such improvements in FHR patterns are often early indicators of fetal recovery from hypoxic stress. These physiological effects establish a strong mechanistic basis for the clinical improvements observed in our study. Additionally, in a randomized prospective trial, reported deterioration in umbilical cord blood gas values after prolonged oxygen administration during the second stage of normal labor, indicating that prolonged or high-exposure oxygen may not always be beneficial.[14] This finding is particularly important, as acidosis is a key marker of fetal hypoxia and predictors of adverse neonatal outcomes. However, more recent studies have produced mixed results. For instance, Moors *et al.* reported improvements in abnormal FHR patterns without a corresponding change in Apgar scores, suggesting that short-term physiological benefits may not always translate into measurable clinical outcomes.[15] Likewise, another study demonstrated non-inferiority of room air in controlling neonatal lactate levels, raising questions about the universal applicability of oxygen therapy.[16] These inconsistencies highlight the importance

of factors such as timing, duration, and dosage of oxygen administration. Two key aspects of our protocol may explain the more pronounced benefits observed. First, oxygen therapy was initiated during the active phase of labor, allowing sufficient time for a sustained diffusion gradient to develop across the placenta. Early initiation may therefore prevent progression of hypoxia rather than attempting reversal at a later stage. Second, the use of moderate-flow oxygen avoids the adverse effects associated with high-flow administration, such as placental vasoconstriction, while still enhancing maternal arterial oxygen levels beyond the plateau of the haemoglobin dissociation curve. This balanced approach appears to optimize efficacy while minimizing potential harm.

Considering role of nasal oxygen at tissue level, it is documented that oxygen augments the partial-pressure gradient across the syncytiotrophoblast, thereby increasing umbilical venous pO_2 and buffering repetitive hypoxic insults generated by uterine contractions. Each uterine contraction transiently reduces uteroplacental blood flow, making the fetus vulnerable to intermittent hypoxia. Khazin *et al.* showed that maternal hyperoxia could increase fetal oxygen tension, indicating that fetal oxygenation does respond to maternal oxygen administration.[17] By increasing the maternal oxygen reservoir, supplementation helps maintain a favorable gradient for diffusion even during these stress periods. Improved fetal heart rate variability observed in our cohort supports the concept of rapid fetal myocardial and autonomic recovery. Variability in FHR is a well-established indicator of adequate oxygenation and intact neurological function, reflecting balanced autonomic control. Enhanced variability therefore suggests that oxygen therapy facilitates quicker recovery from transient hypoxic episodes. At the same time, by increasing dissolved arterial oxygen without inducing maternal hypocapnia or marked hyperoxia—mean SpO_2 remained < 98%—we likely avoided reactive oxygen species–mediated placental vasospasm described when FiO_2 approaches 1.0.[18] This is particularly important, as excessive oxygen can paradoxically impair placental perfusion through oxidative stress–induced vasoconstriction. The controlled, low-flow approach used in our study ensures that benefits are maximized while risks are minimized. The net effect is enhanced fetoplacental gas exchange rather than the paradoxical decline in umbilical venous pO_2 reported with prolonged high-concentration oxygen exposure. This distinction underscores the importance of appropriate dosing and duration in achieving optimal outcomes.

Current intrauterine resuscitation bundles prioritize expeditious delivery for worsening Category III FHR tracings, yet operating-theatre lag times frequently exceed 30 minutes in resource-limited settings. Such delays create a critical window during which fetal compromise may worsen if no interim measures are implemented. In this context, our findings suggest that continuous low-flow nasal oxygen can function as an effective "bridge" intervention. By stabilizing fetal condition, it provides valuable time until definitive obstetric intervention can be carried out. These figures compare favorably with many pharmacologic tocolytics, emphasizing the value of a simple, non-invasive intervention. Four women should be given intrapartum oxygen to avert one poor 5 minute apgar score and 3 women will need continuous oxygen to prevent one NICU admission, indicating a high degree of clinical effectiveness. These findings lend empirical support to intrauterine resuscitation algorithms endorsed by ACOG and FIGO, which recommend maternal oxygen as a first-line measure in suspected reversible fetal hypoxia.[19,20] Integrating such evidence into routine clinical practice can enhance the effectiveness and consistency of labor management strategies.

The need for lower-segment caesarean section was halved (31.3 *vs* 68.8%; $\chi^2 = 7.26$, $p = 0.007$), which has significant implications for reducing maternal morbidity and operative risks. Additionally, neonatal intensive care unit (NICU) admission rates decreased markedly from 45.2 to 7.1% ($\chi^2 = 15.76$, $p < 0.001$), highlighting the potential of this intervention to reduce neonatal complications requiring advanced care. Because baseline socio-demographic and obstetric variables were well matched, these improvements are unlikely to be explained by confounding factors. A recent systematic review and meta-analysis in year 2021 has concluded that there is no difference in rates of cesarean conducted for non-re-assuring fetal heart rates for mothers receiving oxygen or room air. No effect on cesarean rates after use of prophylactic oxygen is also an important conclusion addressed in this study. This study advocates large randomized controlled trials.[21,22]

Association of fetal hypoxia with neurological disorders in the neonate is not clear. Cognitive impairment and depression in adult life may be a result of fetal hypoxia, adhering to Barker's hypothesis; may benefit from prophylactic oxygen.[23]

The associated reduction in emergency caesarean section not only lowers maternal morbidity but also alleviates pressure on high-volume obstetric units. Reduced operative deliveries translate into fewer

complications such as hemorrhage, infection, and prolonged hospitalization. Additionally, decreased NICU admissions reduce both emotional and financial burdens on families while conserving critical care resources.

Conclusion

Within the pragmatic confines of an Indian tertiary labor room, continuous low-flow intrapartum nasal oxygen significantly improved 1 and 5 minutes Apgar scores, stabilised FHR, halved emergency caesareans and reduced NICU utilisation five-fold. These benefits, achieved without measurable harm, position nasal oxygen as a simple, inexpensive adjunct to modern intrapartum care one that could help close the gap in perinatal survival envisaged under the sustainable development goals. Further randomised evidence will refine its place, but our findings provide a compelling rationale for its judicious adoption.

Conflict of Interest

None

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