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Original Research Article

Evaluation of Non-invasive Respiratory Support in Preterm Neonates with Respiratory Distress: Efficacy and Long-term Outcomes

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Abstract

Background: Preterm neonates exhibit a high vulnerability to respiratory distress resulting from lung immaturity, which contributes to considerable morbidity and mortality rates. Nasal Continuous Positive Airway Pressure (CPAP) is increasingly utilized for the management of respiratory distress syndrome (RDS), effectively minimizing the requirement for invasive mechanical ventilation. Data regarding the efficacy and long-term outcomes of these interventions, especially in developing countries, remain limited.

Aim: This research evaluates the efficacy and long-term outcomes of non-invasive respiratory support versus invasive ventilation in preterm neonates experiencing respiratory distress.

Methodology: A retrospective descriptive study was carried out at Department of Paediatrics, Darbhanga Medical College and Hospital in Bihar, India, over a period of 10 months. The research involved 92 preterm neonates born before 37 weeks gestation who exhibited respiratory distress. Neonatal characteristics, respiratory support, maternal factors, and outcomes were systematically collected and analyzed utilizing SPSS. Outcomes of non-invasive ventilation (NIV) and invasive ventilation (IV) groups were compared using Chi-square and Fisher's exact tests.

Results: Among the 92 neonates, 65.2% were provided with non-invasive support, whereas 34.8% needed invasive ventilation. Neonates in the NIV group exhibited significantly reduced mortality (8.3% vs. 59.4%, $p < 0.001$) and morbidity, including necrotizing enterocolitis (8.3% vs. 28.1%, $p = 0.001$), disseminated intravascular coagulation (5.0% vs. 31.3%, $p < 0.001$), and sepsis (33.3% vs. 75.0%, $p < 0.001$) when compared to the IV group. Complications, including intraventricular haemorrhage (0% vs. 12.5%, $p = 0.001$) and nasal trauma (10.0% vs. 31.3%, $p = 0.001$), were significantly reduced in the NIV group.

Conclusion: Non-invasive respiratory assistance for premature infants with respiratory distress is linked to improved clinical outcomes and reduced complications relative to invasive ventilation. The results indicate that non-invasive strategies should be prioritized for respiratory support in this population to minimize mortality and morbidity.

Keywords: Mechanical ventilation, Nasal CPAP, Non-invasive ventilation, Preterm neonates, Respiratory difficulty.

Introduction

The neonatal phase, encompassing the first twenty-eight days of life, is truly vital time for a child's existence. Annually, around 4 million infants perish within the first month of life, constituting over fifty percent of child mortality under the age of five in numerous global locations. Nearly all (99%) newborn fatalities occur in underdeveloped nations [1]. The newborn mortality rate serves as a measure for assessing a nation's health status. According to the Indian National Neonatal-Perinatal Database, the incidence of respiratory distress syndrome is a relatively modest 1.2%, with a 13.5% fatality rate unique to RDS. The population from which this data is derived has a low birth-weight rate of 31.4% and

a preterm birth rate of 14.5%. Prematurity and its consequences account for approximately 88% of all newborn fatalities in Bangladesh. The morbidity and mortality rates of preterm newborns are considerably elevated compared to those of full-term neonates due to a greater susceptibility to respiratory failure. The developmental inadequacy of their pulmonary architecture may result in compromised gas exchange, necessitating breathing assistance. Respiratory distress is a prevalent issue faced by neonates during the initial days of life, necessitating hospital hospitalization. Neonates experiencing respiratory distress have a 2-4-fold increased mortality risk compared to those without respirational distress. In neonates, respiratory difficulty is identified by one or more indicators of elevated respiratory effort, including grunting, tachypnea, nasal flaring, or chest retractions [3]. RDS accounts for 50.8% of cases of respiratory distress in preterm infants, with pneumonia/sepsis coming in at 1.9% and neonatal tachypnea at 4.3%.

Respiratory distress syndrome (RDS) is the leading cause of illness and mortality in newborns, indicating a need for ventilation in preterm infants [4]. The implementation of nasal continuous positive airway pressure (CPAP) as a primary intervention for preterm newborns has significantly transformed respiratory care in the initial hours of life. The increased use of CPAP has led to a reduction in the necessity for mechanical ventilation (MV) and endotracheal intubation, which are associated with lung injury. According to the recommendations from the American Academy of Pediatrics and the European Consensus Guidelines for RDS management, the initial application of CPAP should be viewed as the optimal form of respiratory support [5].

A worry regarding the widespread application of CPAP in preterm newborns is that those with severe RDS may experience a high rate of CPAP failure, necessitating intubation and the initiation of mechanical ventilation. Data from multiple hospital-based cohort studies indicate that CPAP failure correlates with an elevated risk of adverse outcomes, such as pneumothorax, bronchopulmonary dysplasia (BPD), and intraventricular haemorrhage (IVH), compared to the cohort for whom CPAP effectively diminishes the necessity for intubation.

While a conclusive diagnosis of RDS necessitates pathological or biochemical evidence of surfactant deficit, doctors frequently employ a mix of clinical and radiographic characteristics for diagnosis. Clinical signs manifest shortly after birth and involve nasal flaring, cyanosis, subcostal, intercostal retractions, tachypnea, and grunting. In critical instances of RDS, infants may advance to respiratory failure necessitating intubation and mechanical ventilation [7].

All mothers at risk of premature delivery between 24 and 33 weeks and 6 days of gestation are advised to take a single course of prenatal corticosteroids, according to current guidelines. Women who are between 34 and 36 weeks along in their pregnancies, have never used corticosteroids to aid in fontal lung maturation, are expecting a baby in the next seven days, and should follow this course of action [8]. Since betamethasone and dexamethasone are not yet known to be the most effective corticosteroids, additional research is necessary to make this determination. The ideal time to administer corticosteroids is between 24 hours and 7 days before birth, yet they are still beneficial even if given outside of this window [9]. If a woman is at danger of premature delivery before 34 weeks of gestation and her last course of corticosteroids was taken more than 14 days ago, she is currently advised to take a rescue course [10]. The purpose of this study is to evaluate the efficacy of non-invasive respiratory support in preterm neonates with respiratory distress and to assess its impact on long-term outcomes.

Methodology

Study Design

A descriptive study was carried out retrospectively over a duration of 10 months. A total of 92 individuals with clinically suspected neonates with RDS were involved.

Study Area

The current study was carried out in the Department of Pediatrics, Darbhanga Medical College and Hospital, Laheriasarai, Darbhanga, Bihar, India.

Inclusion Criteria

- Preterm newborns born 37 weeks of pregnancy.
- Neonates were declared with respiratory difficulty.

Exclusion Criteria

- Neonates with incomplete data.
- Neonates with lethal congenital anomalies.

Data Collection

Records of newborn admissions, discharges, and deaths were used to collect data. These registers included details such as admission and discharge dates, sex, birth weight, gestational age, mode of delivery, diagnosis, and outcomes. Additional maternal and neonatal variables, such as mode of delivery, APGAR score, respiratory distress, respiratory support, and neonatal morbidities, were also extracted.

Procedure

Neonates with respiratory distress were assessed using standardized definitions for neonatal conditions, including Silverman-Anderson scoring

for respiratory distress and diagnoses like respiratory distress syndrome (RDS), Transient Tachypnea of the Newborn (TTN), and Bronchopulmonary Dysplasia (BPD). Medical and nursing staff were oriented in the data recording process and clinical guidelines. The maximum level of breathing support for every newborn was recorded.

Statistical Analysis

Data analyses were conducted utilizing SPSS software, version 27. Categorical variables were represented as frequencies and analyzed with the Chi-Square test or Fisher's exact test, whereas continuous variables were presented as means (± SD) and analyzed using a student's t-test. A p-value below 0.05 is deemed statistically significant.

Result

Table 1 displays the baseline neonatal characteristics of 92 studied neonates, revealing a mean gestational age of 32.39 weeks (± 2.46) with the majority (39.10%) being ≥37 weeks. Birth weights averaged 1631.44 grams (± 578.57), with 41.30% falling within the 1500–2499 g range and only 15.20% weighing ≥2500 g. In terms of gender distribution, 55.40% of the neonates were male. A small proportion required neonatal resuscitation (9.80%), and multiple births accounted for 6.50% of cases. Most neonates had an APGAR score of ≥7 at five minutes (93.50%), while the Silverman Anderson Score indicated that 58.70% scored between 4 and 7. Surfactant administration was required in 4.30% of the cases.

Table 1: Baseline neonatal features in the examined newborns

Parameter	Value (n)	Percentage (%)
Birth weight (g)	1641.94 ± 568.57	
Birth weight groups		
≥2500 g	14	15.20%
1500–2499 g	38	41.30%
1000–1499 g	36	39.10%
<1000 g	4	4.30%
Gestational age (weeks)	37.38 ± 2.45	
Gestational age groups		
≥37 weeks	36	39.10%
34–<37 weeks	33	35.90%
28–<34 weeks	21	22.80%
<28 weeks	2	2.20%
Gender		
Female	41	44.60%
Male	51	55.40%
Neonatal resuscitation	9	9.80%
Multiple Birth	6	6.50%
Silverman Anderson Score at randomization		
>7	20	21.70%
4–7	54	58.70%
0–3	18	19.60%
APGAR score at 5th minute		
<7	6	6.50%
≥7	86	93.50%
Surfactant administration	4	4.30%

Table 2 presents baseline maternal characteristics of the studied group. Consanguinity was observed in 1 participant (1.10%). Among the mothers, the majority were multiparous (67.40%, n=62), while 32.60% (n=30) were primiparous. Regarding exposure to Antenatal Care Services (ACS), 51.10% (n=47) reported no exposure, 31.50% (n=29) had incomplete exposure, and 17.40% (n=16) had complete exposure. The mode of delivery indicated that a significant majority underwent lower uterine caesarean section (LUCS) at 80.40% (n=74), compared to 19.60% (n=18) who had normal vaginal delivery (NVD). Additionally, 23.90% (n=22) had risk factors for sepsis, with pregnancy-induced hypertension (PIH) affecting 69.60% (n=64) and gestational diabetes mellitus (GDM) noted 14.10% (n=13) of the participants.

Table 2: Baseline features of mothers in studied group		
Parameter	**Value (n)**	**Percentage (%)**
Consanguinity present	1	1.10%
Parity		
Multipara	62	67.40%
Primipara	30	32.60%
Exposure to ACS		
None	47	51.10%
Incomplete	29	31.50%
Complete	16	17.40%
Mode of delivery		
LUCS	74	80.40%
NVD	18	19.60%
Risk factors for sepsis	22	23.90%
PIH	64	69.60%
GDM	13	14.10%

Table 3 shows the primary diseases necessitating respiratory support among the studied neonates. The most prevalent condition was respiratory distress syndrome (RDS), affecting 46 infants, which accounts for 50.00% of the cases. Following RDS, 23 infants (25.00%) experienced transient tachypnea of the newborn, while congenital pneumonia was identified in 17 infants (18.50%). Perinatal asphyxia was recorded in 6 cases (6.50%), and notably, there were no instances of meconium aspiration syndrome among the participants. Regarding the level of respiratory support provided, non-invasive support was utilized in 60 neonates (65.2%), while invasive support was required for 32 infants (34.8%), indicating a preference for non-invasive methods in managing respiratory distress in this cohort.

Table 3: Major disease requiring respiratory assistance		
Parameter	**Value (n)**	**Percentage (%)**
Meconium aspiration syndrome	0	0.00%
Perinatal asphyxia	6	6.50%
Congenital Pneumonia	17	18.50%
Transient tachypnoea of newborn	23	25.00%
RDS	46	50.00%
Degree of respiratory assistance		
Invasive support	32	34.8%
Non-invasive support	60	65.2%

Table 4 compares the mortality and morbidity of neonates requiring respiratory support between two groups: the Non-Invasive Ventilation (NIV) group (n=60) and the Invasive Ventilation (IV) group (n=32). In-hospital mortality was significantly lower in the NIV group at 5 (8.3%) compared to 19 (59.4%) in the IV group ($P < 0.001$). The incidence of Necrotizing Enterocolitis (NEC) was also higher in the IV group, with 9 (28.1%) cases versus 5 (8.3%) in the NIV group ($P = 0.001$). Although Acute Kidney Injury (AKI) rates were similar between groups (8 [13.3%] in NIV vs. 6 [18.8%] in IV, $P = 0.33$), the NIV group had significantly lower occurrences of Disseminated Intravascular Coagulation (DIC) at 3 (5.0%) compared to 10 (31.3%) in the IV group ($P < 0.001$), Septic Shock (9 [15.0%] vs. 20 [62.5%], $P < 0.001$), and Sepsis (20 [33.3%] vs. 24 [75.0%], $P < 0.001$). The prevalence of Patent Ductus Arteriosus (PDA) did not differ significantly between the two groups, with 11 (18.3%) in the NIV group and 8 (25.0%) in the IV group ($P = 0.39$).

Table 4: Mortality and morbidity associated with infants requiring respiratory support			
Parameters	**IV group (n=32)**	**NIV group (n=60)**	**P-value**
In-hospital mortality	19 (59.4%)	5 (8.3%)	<0.001
NEC	9 (28.1%)	5 (8.3%)	0.001
AKI	6 (18.8%)	8 (13.3%)	0.33
DIC	10 (31.3%)	3 (5.0%)	<0.001
Septic Shock	20 (62.5%)	9 (15.0%)	<0.001
Sepsis	24 (75.0%)	20 (33.3%)	<0.001
PDA	8 (25.0%)	11 (18.3%)	0.39

Table 5 represents complications associated with two respiratory support modalities in preterm neonates: Invasive Ventilation (IV) and Non-Invasive Ventilation (NIV). In the NIV group (60 neonates), no cases of Intraventricular Hemorrhage (IVH) or Pneumothorax were reported, while the IV group (32 neonates) had 4 cases of IVH (12.5%) and 1 case of Pneumothorax (3.1%), with a statistically significant difference in IVH incidence (p = 0.001). For Bronchopulmonary Dysplasia (BPD), the NIV group reported 1 case (1.7%) compared to 3 cases (9.4%) in the IV group (p = 0.097), which is not statistically significant. Retinopathy of Prematurity (ROP) occurred in 3 cases (5.0%) in the NIV group and 6 cases (18.8%) in the IV group (p = 0.016), indicating a significant difference. Nasal trauma was reported in 6 cases (10.0%) in the NIV group and 10 cases (31.3%) in the IV group, also showing significant difference (p = 0.001). Overall, the NIV group exhibited a lower incidence of complications, particularly IVH, ROP, and nasal trauma, compared to the IV group.

Table 5: Complications of respiratory support modalities in premature neonates

Parameters	IV group (n = 32)	NIV group (n = 60)	P value
IVH	4 (12.5%)	0 (0.0%)	0.001
BPD	3 (9.4%)	1 (1.7%)	0.097
ROP	6 (18.8%)	3 (5.0%)	0.016
Pneumothorax	1 (3.1%)	0 (0.0%)	0.12
Nasal trauma	10 (31.3%)	6 (10.0%)	0.001

Discussion

The results present a comprehensive overview of the baseline characteristics of the participating neonates. An average gestational age of 32.39 ± 2.46 weeks was recorded, with 39.10% of infants delivered at or beyond 37 weeks and 35.90% delivered between 34 and just under 37 weeks. Only 2.20% of individuals were born at 28 weeks gestation. The average birth weight was 1631.44 ± 578.57 grammes, with 41.30% of neonates in the 1500-2499 gramme range, and 4.30% weighing under 1000 grammes. The gender distribution exhibited a slight skew, comprising 55.40% male and 44.60% female participants. A minor percentage (9.80%) necessitated resuscitation at birth, while 6.50% were involved in multiple births. A majority of neonates (93.50%) achieved an APGAR score of 7 or higher at five minutes, reflecting favourable health status, while surfactant administration occurred in only 4.30% of instances. Nemr et al. reported comparable findings, noting a mean gestational age of 33.98 ± 3.44 weeks in 100 cases, along with a similar mean birth weight of 1580 grammes. Their study indicated a higher proportion of males (63%), aligning with Iqbal Q's findings of 60% male neonates. [11-12]

The baseline maternal characteristics show that a significant proportion of mothers were multipara (67.40%), indicating previous pregnancies. Only 1.10% exhibited a history of consanguinity. Regarding antenatal corticosteroid (ACS) exposure, 51.10% of mothers indicated no exposure, 31.50% reported incomplete exposure, and 17.40% were fully exposed. The lower uterine caesarean section (LUCS) was the predominant mode of delivery, representing 80.40% of total deliveries. Furthermore, 23.90% of mothers exhibited risk factors for sepsis, while 69.60% had a history of pregnancy-induced hypertension (PIH) and 14.10% were diagnosed with gestational diabetes mellitus (GDM). A study by Nemr et al. indicated that 29% of births were multiple, 62% were LUCS deliveries, and 29% of mothers had sepsis risk factors. Lategan et al. reported that 17.3% of infants born prior to 34 weeks received optimal antenatal steroid exposure, 60.3% of deliveries were conducted via caesarean section, and 43.6% of mothers experienced hypertension. [13]

The primary respiratory conditions requiring support were analysed, with RDS being the most frequent, affecting 50% of the neonates. Transient tachypnoea of the newborn impacted 25% of the participants, while congenital pneumonia and perinatal asphyxia accounted for 18.5% and 6.5% of cases, respectively. Nemr et al. reported a similar distribution with RDS at 50%, sepsis at 38%, asphyxia at 8%, and pneumonia at 4% [14]. In terms of treatment, 14% received oxygen support via nasal cannula, 72% of patients received continuous positive airway pressure, and 14% required mechanical aeriation [11].

Analysis of mortality and morbidity in neonates requiring respiratory support revealed significant differences between the invasive ventilation (IV) and non-invasive ventilation (NIV) groups. The NIV group had a substantially lower in-hospital mortality rate (8.3%) compared to the IV group (59.4%), along with lower rates of complications like necrotizing enterocolitis (NEC), disseminated intravascular coagulation (DIC), septic shock, and sepsis, all with statistically significant associations. Mortality in ventilated neonates in this study was 60%, closely aligning with findings by Hossain et al., who reported a 70.6% mortality rate [14]. The increased occurrence of necrotizing enterocolitis (NEC), sepsis, septic shock, disseminated intravascular coagulation (DIC), and in-hospital

mortality among the mechanically ventilated group aligns with findings from other studies as well [15].

The complications related to the modality of respiratory support were also investigated, revealing that the NIV group experienced no instances of intraventricular haemorrhage (IVH), whereas 12.5% of the IV group did. Other complications such as retinopathy of prematurity (ROP) and nasal trauma were significantly more common in the IV group, highlighting potential risks associated with invasive ventilation methods. The findings underscore the critical need for effective management strategies in neonates requiring respiratory support, emphasizing the benefits of non-invasive techniques where feasible. Overall, the data presents a detailed picture of the neonatal population and their maternal backgrounds, providing insights into health outcomes and complications related to respiratory support in this vulnerable group.

Conclusion

This study assesses the efficacy and long-term outcomes of non-invasive respiratory support in preterm neonates experiencing respiratory distress, emphasizing notable differences in clinical outcomes between invasive ventilation (IV) and non-invasive ventilation (NIV) groups. The findings demonstrate that neonates undergoing non-invasive ventilation (NIV) had reduced rates of in-hospital mortality, necrotizing enterocolitis, disseminated intravascular coagulation, septic shock, and sepsis in comparison to those receiving invasive ventilation (IV), indicating that NIV correlates with improved immediate outcomes. Furthermore, complications including intraventricular hemorrhage and nasal trauma were significantly reduced in the NIV group, reinforcing the preference for non-invasive approaches in the management of respiratory distress in this at-risk population. The findings highlight the significance of non-invasive techniques in decreasing morbidity and mortality, supporting their wider adoption in clinical practice for preterm neonates.

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