The Outcome of Continuous Positive Airway Pressure (CPAP) in Preterm Neonates in Central India - A Prospective Study

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ABSTRACT

BACKGROUND

Neonatal respiratory distress syndrome (RDS) is among the common complications in infants born before 37 weeks. In India the incidence of RDS ranges from 0.69 - 8.3 %. CPAP is a less invasive method frequently used in premature infants having RDS). We wanted to assess the outcome of preterm neonates treated with CPAP.

METHODS

Prospective observational study was done in NICU of a tertiary care hospital, Raipur, Chhattisgarh in central India, during April-2014 to April-2015. Eligible Children were included in the study and evaluated using SAS (Silverman Anderson Scoring), blood gas analysis and pulse oximetry. Quantitative variables were presented as mean and standard deviation; categorical variables were presented as frequency and percentages.

RESULTS

Out of total 50 babies on CPAP, 38 improved with success rate of 76 % whereas 12 babies (24 %) failed requiring higher mode of ventilation. CPAP was more successful among females (n = 22) with a success rate of 88.0 %. CPAP proved more effective in moderate grade RDS with success rate of 83.3 % (statistically significant $p < 0.05$). Based on SAS score, shows the improvement in respiratory distress following CPAP.

CONCLUSIONS

Nasal CPAP is safe effective, non-invasive means of respiratory support in RDS. It can considerably decrease the requirement for mechanical ventilation (MV) and surfactant therapy.

KEYWORDS

Respiratory Distress Syndrome, Positive Airway Pressure, Silverman Anderson Score

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BACKGROUND

Preterm birth is defined by World Health Organization (WHO) as any birth before 37 completed weeks of gestation, or fewer than 259 days since the first day of the woman's Last Menstrual Period (LMP). An estimated 15 million infants are born preterm worldwide, with resulting complications.[1] Neonatal respiratory distress syndrome is one of the common complications in infants born before 37 weeks. The more premature the baby is, the higher the chance of RDS after birth.[2] In developed countries like United Sates annual incidence is estimated as 190,000 cases of RDS and a hospital mortality of 38.5 %.[3] Whereas the Indian studies observed an incidence ranging from 0.69 to 8.3 %.[4]

Assisted ventilation and surfactant was the standard treatment for every preterm infants for two decades. But ventilation damages the lungs and leads to bronchopulmonary dysplasia.[5] Therefore another, less invasive method, of continuous positive airway pressure for improving oxygenation in infants with RDS was sought in 1971 by Gregory et al.[6] CPAP is a way of delivering PEEP (Positive End-Expiratory Pressure). CPAP also maintains the set pressure throughout the respiratory cycle, during both inspiration and expiration.[7] The application of CPAP maintains PEEP, can decrease atelectasis, increases the surface area of the alveolus, improves V / Q matching, and hence, improves oxygenation.

CPAP is most often used in premature infants with RDS.[8] Bubble CPAP is a newer technique in which CPAP is delivered by CPAP system with underwater seal.[9]

With the above background the present study was undertaken to assess the clinical profile and various outcome of preterm neonates treated with CPAP.

METHODS

The present hospital based prospective study was carried out in neonatal ICU at tertiary care institute, Raipur Chhattisgarh in central India, during April 2014 to April 2015. For the sample size consideration α (two-tailed) was taken as 0.05, β (type II error) as 0.20, clinical effect size as (E) 0.4 (or 40 % points) and standard deviation of the change in the outcome S (Δ) as 1. Substituting it B = (Zα + Zβ) 2 = 7.849, C = (E / S (Δ)) 2 = 0.160 and B / C = 49.06. Thus, for rounding off we needed 50 participants for the study.

Inclusion Criteria

Preterm neonates of gestational age between 28 - 37 weeks with respiratory distress syndrome admitted in our hospital during study period. All babies were evaluated using SAS (Silverman Anderson Scoring), [10] blood gas analysis and pulse oximetry. Babies with SAS of > 4 or requiring FiO_2 > 0.4 to maintain PaO_2 > 50 - 60 mm of Hg were treated with early nasal CPAP. Infants were nursed underneath radiant warmers on servo-controlled skin mode. CPAP was started with 5 cm H2O and FiO_2 adjusted to maintain pulse oximeter saturations between 88 % to 94 % in < 1.5 Kg and 92 % to 94 % in > 1.5 Kg babies.

Exclusion Criteria

All term neonates, neonates with congenital malformations, babies born to mothers receiving general anaesthesia, phenobarbitone, pethidine and other drugs likely to depress the baby, babies with meconium aspiration syndrome, and babies with birth asphyxia. Institutional ethical clearance was taken. The participation of study subjects were on voluntary basis, participants were recruited from the neonatal ICU. 50 participants fulfilling the inclusion criteria and parents or guardians provided written informed consent were recruited in the study. The study tool was a predesigned and pre-tested structured questionnaire. The details of gestational age, birth weight, risk factors in pregnancy, use of antenatal steroids, type of delivery, need for resuscitation were recorded. Monitoring was done clinically and using pulse oximetry, X-rays and ABGs (Arterial Blood Gases) for requirement of change in settings. Complications, success, failure, age at initiation of CPAP, total period of therapy and time taken to wean were recorded. SAS score before and after treatment was recorded. Trails off CPAP were done before finally discontinuing CPAP. The participants were followed at 6 hours and 12 hours after administration of CPAP.

Definition of CPAP is successful when; Saturation > 85 %, PaO_2 60 - 80 mmHg, $PaCO_2$ of 25 to 45 mmHg and PH of 7.3 - 7.4 with FiO_2 of < 0.6. Baby has no respiratory distress. Definition of CPAP failure is defined as; PaO_2 < 50 mmHg or PCO_2 > 60 mmHg with FiO_2 of > 0.6, SAS score > 6, Recurrent apnoea.

Statistical Analysis

The data was entered in Microsoft excel 2007. Continuous variable was summarized using mean & SD (Standard Deviation) while the categorical variables as percentage & proportion. For showing the association between before and after analysis paired-t test was applied on continuous variables while McNemar chi-square test was applied for categorical variables. P value is less than 0.05 was considered as significant.

RESULTS

50 participants were recruited during the study period. Table 2 shows that out of total 50 babies on CPAP, 38 improved with statistically significant success rate of 76 % whereas 12 babies (24 %) failed requiring higher mode of ventilation (76 % vs. 24 %, p < 0.002). It was observed that CPAP was more successful among females (n = 22) with a success rate of 88.0 % as compared to 64 % in males (n = 16). However, it was statistically non-significant (p = 0.168). The mean age for initiation of CPAP treatment among all 50 study subjects was 3.31 hours with range 0.5 - 6 hours. The mean duration of CPAP treatment was significantly high among (< 0.001) success group which was 35.31 ± 14.09 hours as compared

ABG Parameter	Before CPAP (Mean ± SD)		P-Value Success Vs. Failure (t-test)	After CPAP (Mean ± SD)		P-Value Success Vs. Failure (t-test)	P-Value Success Before Vs. After (Paired Test)	P-Value Failure Before Vs. After (Paired Test)
	Success	Failure		Success	Failure			
pH	7.268 ± 0.079	7.314 ± 0.199	0.178	7.379 ± 0.05	7.319 ± 0.1188	0.0733	< 0.001	0.94
PO_2	57.66 ± 10.58	55.93 ± 10.96	0.659	80.48 ± 7.52	42.16 ± 18.83	0	< 0.001	0.03
PCO_2	41.31 ± 11.14	36.99 ± 10.42	0.27	30.62 ± 6.67	38.40 ± 9.73	0.036	< 0.001	0.73
HCO3	18.377 ± 0.97	18.56 ± 0.81	> 0.05	20.507 ± 1.149	17.15 ± 0.83	< 0.001	< 0.001	0.006

Table 1. Comparison of ABG Parameters before and after Treatment in Success and Failure Group

to failure group which was 8.66 ± 1.5 hours, range being 8 - 12 hours. Among the 38 babies with successful CPAP, 23 (60.5 %) had received antenatal steroids while among 12 babies with CPAP failure 6 (50 %) had received antenatal steroids. As per gestational age, 15 babies belonged to 28 - 30 weeks, 11 were in 31 - 32 weeks' gestation and remaining 24 were of 33 - 37 weeks gestational age. Significantly higher success rate of CPAP (83.33 %) was found among babies of 33 – 37 weeks of gestation. Similarly, as per birth weight, statistically higher success rate (87.5 %) of CPAP was found in babies with birth weight of more than 1500 gm. Based on radiological appearance, early nasal CPAP proved more effective in moderate grade RDS with success rate of 83.3 % (statistically significant $p < 0.05$). Table 1 shows arterial blood gas analysis of babies which shows significant increase in oxygenation ($p < 0.05$) after application of CPAP. Table 3 shows, before the CPAP, none of the study subjects had SAS score less than 4. Nasal CPAP was started on all babies with SAS score 4 or more. At the end of 6 hours 24 babies (52 %) on CPAP converted to SAS score < 4. This shows the improvement in respiratory distress following CPAP. After 12 hours of CPAP, 43 (86 %) subjects had converted to SAS score of < 4. The results of test were statistically significant, $p < 0.01$.

Demographic Factors		No.	% (95 % CI)
Gender	Male	25	50 % (36.6 % - 63.3 %)
	Female	25	50 % (36.6 % - 63.3 %)
Gestational Age (weeks)	< 33	26	52 % (38.5 % - 65.3 %)
	> = 33	24	48 % (34.8 % - 61.3 %)
Birth Weight (Kg)	< 1.5	26	52 % (38.5 % - 65.3 %)
	> = 1.5	24	48 % (34.8 % - 61.3 %)

Table 2. Demographic Factors of the Study Participants

SAS Score	No. of Study Subjects Before CPAP		after 6 hr. of CPAP		After 12 hr. of CPAP	
	No.	% (95 % CI)	No.	% (95 % CI)	No.	% (95 % CI)
< 4	00	00	24	52 % (38.5 % - 65.3 %)	43	86 % (73.8 % - 93.05 %)
> = 4	50	100 (92.8 % - 100 %)	26	48 % (34.8 % - 61.3 %)	07	14 % (6.9 % - 26.2 %)

Table 3. Distribution of Study Subjects Based on SAS Score before and after CPAP Treatment

Effect of Antenatal Steroid		CPAP Outcome: Success (N = 38) No.	% (95 % CI)	Failure (N = 12) No.	% (95 % CI)
Antenatal Steroids	Yes	23	60.5 % (44.7 % - 74.4 %)	06	50% (25.3 % - 74.6 %)
	No	15	39.5 % (25.6 % - 55.3 %)	06	50% (25.3 % - 74.6 %)

Table 4. Effect of Antenatal Steroid on the CPAP Outcome

Chi-square value = 0.4148, df = 1, p-value = 0.51

DISCUSSION

In our study, out of total 50 babies CPAP was more successful among females (n = 22) with a success rate of 88.0 % as compared to 64 % in males (n = 16). While a greater number of males (59.3 %) with RDS was observed by Sambhaji et al [11] as compared to females. Similarly, study done by Urset al[12] 66 % were males and 34 % females and study done by Balajietal[13] 60 % male and 40 % females which was comparable. In our study, the babies who were between 28 - 30 weeks of gestation, the overall success of CPAP was 66.67 %, babies between 31 - 32 weeks' gestation showed 72.72 % success rates and in 33 - 36 weeks, success rate of CPAP was 83.3 %. Similar findings were observed by Sambhaji et al.[11] Balaji et al,[13] concluded that early institution of CPAP in management of RDS with preterm, can reduce mechanical ventilation and surfactant use. Also, Jagdish kotietal[14] observed that CPAP was safe for preterm infant with RDS. Sandri F et al[15] concluded that in newborns of 28 - 31 weeks' gestation, there is no greater benefit in giving prophylactic CPAP than in starting CPAP when the oxygen requirement increases to a $FiO_2 > 0.4$.

In a retrospective study by Ammari, et al[16] all the infants with gestation > 30 weeks survived on CPAP. In their study nearly 65 % of the babies were ELBW (Extremely Low Birth Weight) and 85.5 % of babies had gestation less than 30 weeks as against 17.9 % and 39.3 % respectively in study by Koti et al.[14] Urs et al[12] have found better outcome in gestational age of 32 - 34 weeks ($p < 0.001$). In our study, higher success rate (87.5 %) of CPAP was found in babies with birth weight of more than 1500 gm. Aly H et al[17] studied outcome of nasal CPAP in ELBW. They found no significant trends in mortality rate among the baseline group and the 3 groups after the institution of the nasal CPAP practice. Study by Narendran V et al[18] has also shown better outcomes in ELBW. Another study by Joris N et al[19] has shown significant reduction in intubation rate in babies < 1500 g (from 72.1 % to 30.8 %; $p < 0.01$). Urs et al[12] have shown better outcome in babies with birth weight 1000 - 1500 gm ($p < 0.001$). In our study we did not find any significant difference in the outcome of babies based on birth weight ($p > 0.05$). In our study, based on radiological appearance, early nasal CPAP proved more effective in moderate grade RDS with success rate of 83.3 % (statistically significant $p < 0.05$). In severe grade HMD (Hyaline Membrane Disease) out of 13 babies 61.54 % was the success. Boony et al[20] showed that there are three risk factors which were significantly associated with unsuccessful CPAP. These were: moderate or severe RDS (odds ratio 5.9; 95 percent; CI 1.5

- 50.7); and pneumothorax during CPAP therapy (odds ratio 6.9; 95 per cent; CI 1.1 - 41.7).

In our study, Table 4, among the 38 babies with successful CPAP, 23 (60.5 %) had received antenatal steroids while among 12 babies with CPAP failure 6 (50 %) had received antenatal steroids, though non-significant statistically. Study by Sandri F etal[15] has shown trend towards greater failure in babies who had not received antenatal steroids ($p = 0.02$). Ursetal[12] have also shown that CPAP is more effective in babies of mothers who have received antenatal steroids. Kotietal[14] had similar findings. In a case-control study by Boony et al[20] 34 % of the infants in the study received antenatal steroids.

In our study, 50 preterm babies with gestational age 28 – 36 weeks with HMD were treated with early nasal CPAP. Out of 50 babies, 38 babies (76 %) were effectively managed with early nasal CPAP alone. Remaining 12 (24 %) had to be intubated and required more invasive mechanical ventilation. Study by Narendran V et al[18] showed early bubble CPAP reduced the need for mechanical ventilation ($p < 0.001$) with no increased complications. One study by Nair et al[21] showed failure rates of 10.7 % in newborns with respiratory disease. They used nasal CPAP using Benveniste's valve. In another recent study by Ursetal[12] CPAP proved to be effective in 80 % cases with HMD. In a study by Imani et al[22] 6 (15 %) neonates who received only nasal CPAP (NCPAP) and 4 (10 %) patients who received NCPAP plus surfactant required ventilation therapy.

CONCLUSIONS

Nasal CPAP is safe effective, non-invasive means of respiratory support in RDS. To prevent barotraumas and to reduce the severity of BPD, efforts are being made to decrease the utilization of mechanical ventilation during the first days of life; instead early establishment of NCPAP should be considered. So, our study recommends use of early nasal CPAP for effective management of respiratory distress syndrome in preterm newborns.

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SST raised the initial research question, refined research questions, planned study design, managed data collection, and suggested issues in the discussion. RKV wrote the manuscript, interpreted results, ran statistical analysis, and drew tables and graphs.

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