Al-Rafidain J Med Sci. 2024;7(1):209-214.
DOI: https://doi.org/10.54133/ajms.v7i1.1179

A J M S

Online ISSN (2789-3219)

Research Article

Efficacy and Outcome of Oxygen Delivery Devices in Respiratory Distress in Newborn Babies in a Rural Hospital, India

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Received: 10 July 2024; Revised: 19 August 2024; Accepted: 1 September 2024

Abstract

Background: Respiratory distress is a typical presentation in newborn intensive care units, necessitating mechanical ventilation. Once the baby's condition improves, they are put on oxygen therapy. Nasal cannulas and oxygen hoods are the most commonly used and time-tested methods of providing oxygen treatment. ***Objectives***: To assess the efficacy and outcome of these two devices, as well as their impact on several parameters such as desaturation, heart rate, blood gas anomalies, and adverse effects. ***Methods***: This was a prospective, comparative, interventional study conducted in a rural hospital in Sawangi Meghe, Wardha, Maharashtra. ***Results***: Males accounted for 59% of the 88 infants. The majority of newborns had gestational ages between 28 and 32 weeks. Desaturation episodes were more frequent in patients using nasal cannula. In the nasal cannula group, 8 individuals experienced bradycardia, compared to 11 in the oxygen hood. In total, 24 individuals had abnormal blood gas levels. Nasal cannulas were associated with more nose injuries (27.27%) than oxygen hoods (4.5%). Severe-grade injuries were more reported in low birth weight and premature birth patients. The nasal cannula is more convenient and acceptable to nurses. ***Conclusions***: Nasal cannulas may injure the mucosa, yet they are more effective than hoods. Two kinds of oxygen therapy had little effect on heart rate or blood gas levels.

Keywords: Biophysical profile, Hypoxia, Heart rate variability, New-born, Nasal injuries, Oxygen delivery devices.

فعالية ونتائج أجهزة توصيل الأكسجين في الضائقة التنفسية عند الأطفال حديثي الولادة في مستشفى ريفي، الهند

الخلاصة

الخلفية: الضائقة التنفسية هي عرض نموذجي في وحدات العناية المركزة لحديثي الولادة ، مما يستلزم التهوية الميكانيكية. بمجرد تحسن حالة الطفل، يتم وضعه على العلاج بالأكسجين. قنيات الأنف وأغطية الأكسجين هي الطرق الأكثر استخداما والتي تم اختبارها عبر الزمن لتوفير العلاج بالأكسجين. **الأهداف**: تقييم فعالية ونتائج هذين الجهازين، بالإضافة إلى تأثيرهما على العديد من المعلمات مثل عدم التشبع ومعدل ضربات القلب وشذوذ غازات الدم والآثار الضارة. **الطريقة**: كانت هذه دراسة مستقبلية ومقارنة وتدخلية أجريت في مستشفى ريفي في ساوانجي ميغي، واردها، ماهاراشترا. **النتائج**: شكل الذكور 59٪ من 88 رضيعا. كان لدى غالبية الأطفال حديثي الولادة أعمار حمل تتراوح بين 28 و 32 أسبوعا. كانت نوبات عدم التشبع أكثر تواترا باستخدام قنيات الأنف. في مجموعة قنية الأنف، عانى 8 أفراد من بطء القلب، مقارنة ب 11 في غطاء الأكسجين. في المجموع ، كان لدى 24 فردا مستويات غير طبيعية من غازات الدم. ارتبطت قنيات الأنف بإصابات أنف أكثر (27.27٪) من أغطية الأكسجين (4.5٪). كانت الدرجات الشديدة مرتبطة عادة بانخفاض الوزن عند الولادة والولادات المبكرة. قنية الأنف أكثر ملاءمة ومقبولة للممرضات. **الاستنتاجات**: قنية الأنف قد تجرح الغشاء المخاطي ، لكنها أكثر فعالية من الفلنسوات. كان لنوعين من العلاج بالأكسجين تأثير ضئيل على معدل ضربات القلب أو مستويات غازات الدم.

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Article citation: Lakra MS, Taksande A, Lakra A, Karotkar S, Meshram R, Prasad R, Wanjari M. Efficacy and Outcome of Oxygen Delivery Devices in Respiratory Distress in Newborn Babies in a Rural Hospital, India. *Al-Rafidain J Med Sci.* 2024;7(1):209-214. doi: https://doi.org/10.54133/ajms.v7i1.1179

INTRODUCTION

A challenge in managing respiratory distress in neonates is the requirement of gentle ventilation and strict adherence to the prescribed oxygen therapy, especially for infants weighing less than 1500 grams [1]. CPAP machines and HFFNCs have revolutionized the approach to care for premature infants in underdeveloped nations [2,3]. In order to minimize the danger of failure and potential harm to the organs, it is important to gradually wean babies with respiratory distress from a high fraction of

inspired oxygen (FiO_2). This is because these babies are unintentionally exposed to a high level of FiO_2, which increases their susceptibility to free radical injury and organ damage [4,5]. It is important to regularly monitor the babies undergoing oxygen therapy using pulse oximetry. These babies should be given oxygen within a specified range of suggested saturation, as advised by experts [6,7]. Nasal cannulas and oxygen hoods are the most often utilized and very promising technologies for babies. The nasal cannula delivers oxygen through short tubes that are inserted loosely into the nostrils and is considered the most convenient, efficient, and cost-effective method [8-10]. The oxygen hood is an effective method for delivering oxygen, but it has the potential risk of carbon dioxide buildup at low flow rates and can impede nursing activities such as feeding, suctioning, and regular care. Due to inadequate research in the Indian rural setting comparing two traditional modalities directly, this study was conducted to evaluate the effectiveness, heart rate profile, oxygen saturation, blood gas variation, risk of nose injuries, and staff awareness associated with these two devices.

METHODS

Study design and setting

This study utilized a cross-sectional, prospective, and comparative design that lasted for ten months, namely from December 2021 to September 2022. The investigation was conducted in the rural area of Sawangi Meghe, Wardha, which is located in the Vidarbha region of Maharashtra, India. The primary focus of the study was on patients from surrounding villages. The reporting and article preparation for the cross-sectional elements of the study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Guidelines. The research was carried out in the Department of Neonatology, Acharya Vinoba Bhave Rural Hospital, located in Sawangi (Meghe), Wardha, Maharashtra. The study has been registered with the IEC Institute and assigned the reference number DMIMS(DU)/IEC/2021/657.

Selection criteria and study population

The study included a cohort of 88 preterm infants. The study obtained informed consent from the parents of the infants. Prior to commencing the investigation, an ethical clearance certificate was acquired from the Institutional Ethics Committee (IEC) with the reference number DMIMS(DU)/IEC/2021/659. Only infants who met the specified criteria were included in the study after getting written agreement from their parents. According to the specified criteria for inclusion, all preterm babies born before 37 weeks of gestation who have been successfully taken off continuous positive airway pressure (CPAP) and are in a stable condition in terms of their cardiovascular system were included in the study. On the other hand, the criteria for excluding participants were parents who did not provide consent for the study, infants with choanal atresia and congenital muscle weakness, infants with significant or many congenital abnormalities, and infants who were unwell or hemodynamically unstable.

Data sources and variables

Once written informed agreement was obtained from the babies' family members, those who met the specified criteria were included in the study. The infants were separated into two cohorts, with one group getting oxygen by nasal cannula and the other using oxygen hoods at flow rates of 1-2 liters and 5 liters per minute, respectively. This was done to maintain the desired oxygen saturation level between 91% and 95%. Infants were monitored for signs of cyanosis, desaturation, apneic episodes, and any other clinical deterioration. If such events occurred, they were promptly transitioned to more advanced respiratory support modes such as CPAP and HFNC, and all necessary precautions were implemented to prevent any more decline. The subjects were monitored continuously for 96 hours, during which multiple variables were documented. Individuals who completed a cumulative period of 96 hours without any signs of negative effects or decrease in oxygen levels were classified as successful. The investigators and crew diligently maintained continuous monitoring of the baby using a saturation probe that remained attached at all times. In addition, we conducted a small-scale survey including 30 nurses and junior residents working in our Neonatal Intensive Care Unit (NICU) to examine their replies to the case, as well as the pros and cons of using nasal cannulas compared to the oxygen hood.

Statistical analysis

The scope of our study encompassed all the pertinent data regarding patients, including gestation, gender, reason for admission, weight, general condition, and clinical presentation. The investigators and personnel on duty recorded the pertinent maternal and newborn histories from the maternal case sheets, and the baby's details were documented over the course of treatment. The pertinent data were documented in a certified performa by the investigator and inputted in spreadsheet format. The study examined several baseline features and variable parameters, including sex, gestation age, birth weight, heart rate, desaturation episode, blood gas analysis, and nasal injuries. These factors were studied in terms of their numerical values, proportions, percentages, mean, and standard deviation. The results were evaluated utilizing an upgraded automated program version. The categorical variables in the data were represented using frequency and percentage, while the continuous data was represented using mean and standard deviation values.

RESULTS

A total of 88 patients were examined, with 44 assigned to each group. The initial demographic features were comparable in both groups. The fundamental qualities and outcomes have been illustrated in Table 1.

Table 1: Patient's basic demographic data in two groups

Characteristics	Nasal cannula	Oxygen hood	*p*-value
Gender			
Male	28(63.63)	24(54.54)	0.556
Female	16(36.37)	20 (45.46)	0.117
Gravida			
Primigravida	18(40.9)	22 (50.0)	
Multigravida	26(59.09)	32(72.72)	0.134
Intramural	28(63.63)	30(68.16)	
Extramural	16(36.36)	14(31.81)	
Mode of delivery			
Normal	52(59.09)	56(63.63)	0.158
Cesarean section (week)	36(40.9)	32(36.36)	
Gestation			
<27	5(11.36)	6(13.63)	0.386
27-32	25(56.81)	24(54.54)	
32-37	14(31.81)	14(31.81)	
Weight of baby (g)			
<1000	5(11.36)	4(9.09)	
1001-1500	18(40.90)	18(40.9)	0.935
1501-2500	21(47.74)	22(50.0)	

Values are expressed as frequencies and percentages.

The success rate, apneic events, hypoxia episodes, and other data have been shown in Table 2. Heart rate variability was observed in 8 (18.18%) individuals in the nasal cannula group, compared to 11 (25.25%) in the oxygen hood group.

Table 2: Different variables of participants in both groups

Parameters	Nasal cannula	Oxygen hood	*p*-value	Inference
Early desaturation episodes	63(59.43)	43(40.56)	0.011	Oxygen hood superior
Late desaturation episodes	61(66.33)	31(33.69)	0.029	Oxygen hood superior
Total desaturation episodes	124	74	0.993	Oxygen hood superior
Overall apneic episodes	53(43.44)	69(56.55)	0.650	More in nasal cannula
ABG abnormalities on CPAP	10(22.72)	14(31.81)	0.338	Not significant
After weaning from CPAP	5(11.36)	6(13.63)	0.436	Not significant
Heart rate variability (beat/min)	129±27	125±26	0.709	Almost comparable
Success rate	34(77.27)	24(54.54)	0.042	Success rate more in nasal cannula
Failure	10(22.72)	20(45.46)		

Values are expressed as frequencies, percentages, and mean±SD.

The distribution of heart rate with mean and standard deviation among males and females and intergroup with confidence interval has been shown in Table 3. Out of the total number of newborns, 24 (31.81%) had an abnormal arterial blood gas (ABG) result. Among these, 10 (22.72%) were in the nasal cannula group and 14 (31.81%) were in the oxygen hood group while receiving CPAP (Figure 1). The recent injuries were classified as moderate grade, resulting from persistent irritation of the nasal mucosa caused by the nasal cannula. Simultaneously, the oxygen hood was rated as grade one due to inadequate humidification and dryness of the nares. Nasal cannulas exhibited a higher prevalence of grade one, two, and three injuries compared to oxygen hoods. Severe injuries were more prevalent in infants with lower birth weights (1230 grams), whereas moderate injuries were observed in infants with an average weight of 1698 grams.

Table 3: Heart rate distribution, standard deviation and confidence interval among two groups

Heart rate	Nasal cannula	Oxygen hood	Total no.	*p*-value
<100	8(18.18)	11(25.25)	19(21.59)	0.437
>100	36(81.81)	33(75.75)	69(78.40)	
Heart rate (beats/min)				
Male	128±29.28	128±29.24	126±29.52	>0.05
Female	133± 23.16	128±22.20	130±22.36	>0.05
Total	129±27.44	125±26.44	127±26.88	>0.05
Group	Observed	Mean±SD	CI 95%	
Nasal cannula	44	129.93±27.56	121.55-138.35	
Oxygen hood	44	125.92±26.18	117.95-133.86	
Total	88	127.92±26.79	122.24-133.59	

Values are expressed as frequencies, percentages, and mean±SD.

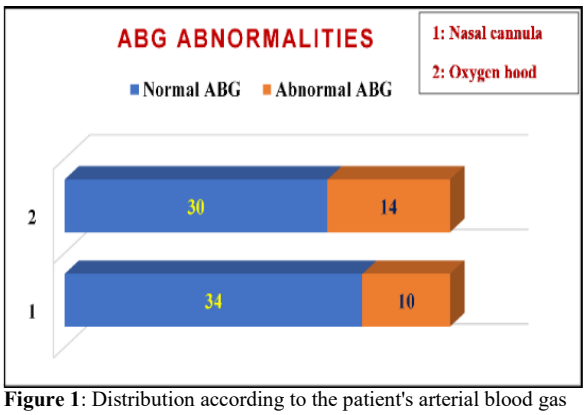

Figure 1: Distribution according to the patient's arterial blood gas (ABG) abnormalities among two groups while on CPAP.

The pCO_2 levels were tested after 24 hours of using a cannula and hood. A total of 5 patients (11.36%) in the cannula group and 6 patients (13.63%) in the oxygen hood group had a pCO_2 level exceeding 45 mmol. However, this difference was not statistically significant (p= 0.338). The hypothesis that the use of oxygen hoods leads to a greater increase in pCO_2 levels compared to nasal cannulas was not supported by the statistical analysis and was therefore rejected. The incidence of nasal injuries was significantly higher in the nasal cannula group, observed in 12 patients (27.27%), compared to the oxygen hood group, observed in 2 patients (4.5%) (Figure 2).

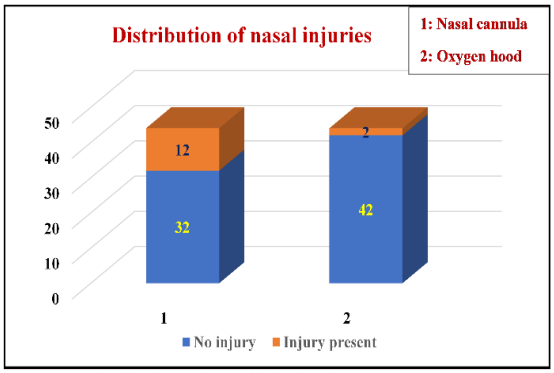

Figure 2: Distribution of nasal injuries in two groups.

The average weight for injuries of categories one, two, and three was 1460±301, 1365±391, and 1230±430 grams, respectively (Table 4). Respiratory distress syndrome was the primary indication for the use of an oxygen hood and nasal cannula. The different underlying causes for hospitalization in the NICU are illustrated in Figure 3, which demonstrates a nearly identical statistical similarity between both groups (*p*=0.928).

Table 4: Pattern of nasal injuries in different weight groups and with both devices

Nasal injuries	Nasal cannula	Oxygen hood	Total no.	*p*-value	Weight wise distribution
Nasal injuries	12(27.27)	2(4.5)	14(100	0.0035	
No. of injuries	32(43.2)	42(56.8)	74(100)	0.290	1698.57±404.91
Grade 1	6(85.7)	1(14.3)	7(100)	<0.001	1460.1±301.37
Grade 2	5(83.3)	1(16.7)	6(100)	<0.001	1365.9±391.45
Grade 3	1(100)	0(0.0)	1(100)	---	1230±430.31

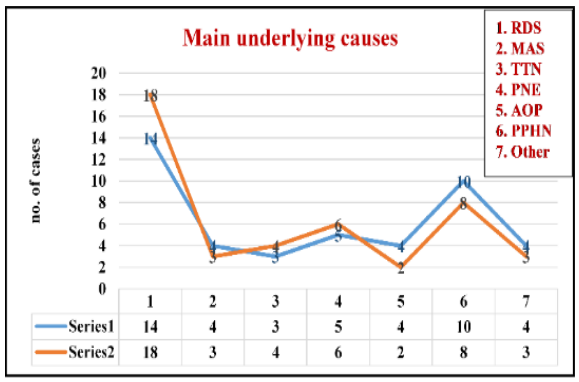

Figure 3: Distribution according to the main underlying causes of illness. EDS: respiratory distress syndrome, MAS: Meconium aspiration syndrome, TTN: Transient tachypnea of newborn, PNE: Pneumonia, AOP: apnea of prematurity, PPHN: persistent pulmonary hypertension.

We conducted a limited-scale study that included 30 nurses and junior residents employed in our Neonatal Intensive Care Unit (NICU). We analyzed the feedback received regarding the case, as well as the pros and cons of using a nasal cannula in comparison to an oxygen hood. The findings are summarized in Table 5. Based on comments from the employees, the nasal cannulas were found to be more practical, simple to use, and effective.

Table 5: Distribution according to KAP survey of working nursing staff and residents

Parameters	Nasal cannula n(%)	Oxygen hood n(%)	*p*-value
Easy to use	24(80.0)	6(20.0)	<0.001
Safety and convenient	25(83.83)	5(16.66)	<0.001
Desaturation episodes	16(53.33)	14(46.66)	0.796
Cost-effectiveness	18(60.0)	12(40.0)	0.196
Overall success	20(66.66)	10(3.34)	0.019
Nasal injuries	28(93.33)	2(6.66)	<0.001
Preferences	25(83.83)	5(16.66)	<0.001
Oxygen consumption	4(13.13)	26(86.66)	<0.001
Patient acceptance	24(80.0)	6(20.0)	<0.001

KAP: knowledge awareness and practices

DISCUSSION

In our study, the majority of patients were male babies, with a ratio of 1.44 per 1 female baby. The majority of infants were in a gestational group ranging from 28 to 32 weeks. Nasal cannulas have been proven to be more effective in preventing apnea but less effective in preventing episodes of desaturation. The possible cause could be the air leakage surrounding the nasal cannulas, which may also result in positive end-expiratory pressure (PEEP) and an increase in lung fractional residual capacity. The oxygen hood delivers a greater fraction of inspired oxygen (FiO_2) and ensures consistent oxygen concentration in the vicinity of the baby's airways. Nasal cannulas are more effective than oxygen hoods in reversing continuous positive airway pressure (CPAP) in cases of respiratory distress. The average heart rate in the group using nasal cannulas was 129±27 beats per minute for males and females. In contrast, the average heart rate in the group using the oxygen hood was 124±29 beats per minute for males and females. Yllescas *et al*. [11] also reported similar findings, showing no significant differences in heart rate, blood pressure, or clinical parameters between infants at 48 and 72 hours of age. In line with the index study, Travers *et al*. [12] observed that there was no discernible disparity in heart rate variability between the use of a nasal cannula (117 *vs*. 130) and being in an oxygen atmosphere (6±7 and 6±5). Hensey *et al*. [13] determined that oxygen completely avoids desaturation by 100% when compared to air, and their findings were consistent with previous research. Based on these observations, we have determined that the devices generally have no impact on heart rate and vital parameters. Upon analyzing the blood gas anomalies 24 hours after using nasal cannulas and hoods, we found that only 5 (11.36%) patients in the nasal cannulas group and 6 (13.63%) patients in the oxygen hood group had pCO_2 values exceeding 45 mmol. However, these differences were not statistically significant. A study conducted by Yllescas *et al*. discovered that these devices, similar to the index study [11], did not exhibit any noteworthy aberrations in blood gas. The study concluded that while an oxygen hood is an effective method for administering oxygen and providing respiratory support, it has the potential risk of carbon dioxide buildup at a low flow rate. The current study did not see any noticeable disparity in blood gas abnormalities. One possible explanation for this could be that the oxygen flow rate administered to the hood group was 4-5 liters, whereas the nasal cannula group received 1-2 liters per minute. The primary etiology of the illness in both cohorts was respiratory distress syndrome, apnea of prematurity, and pneumonia, which exhibited a high degree of similarity between the two groups. The predominant manifestation observed was respiratory distress syndrome. Yllescas *et al*. [11] also observed similar results, with two groups showing respiratory distress syndrome and atelectasis, and one group in each showing respiratory acidosis, apnea of prematurity, desaturation, and pneumonia. Nasal injuries were predominantly associated with the use of the nasal cannula. The injuries were categorized based on Fischer's classification [14]. In our study, the overall occurrence of nasal injuries was shown to be 15.90%. The majority of these injuries were caused by CPAP. The newly acquired injuries were classified as minor due to the ongoing irritation caused by the cannula on the previously weakened mucosa. Nasal injuries were predominantly associated with the use of nasal

cannulas. Yllescas *et al*. [11] observed that nasal injuries were more commonly connected with the use of nasal cannula (48.5%) compared to the use of a hood (11.8%). The injuries consisted of nasal bleeding, swelling of the nasal mucosa, nasal bleeding, and swelling and blockage. A greater number of patients experienced injuries in the nasal group compared to the oxygen hood group after they had been successfully weaned off. Nevertheless, the injuries were exceedingly minor. It is important to highlight that patients who already have injuries when using CPAP will experience an intensified reaction in the nasal lining if they are switched to nasal prongs. This is because the constant pressure and irritation on the nasal mucosa will cause an excessive response. Severe injuries were predominantly observed in infants weighing 1230 g, since their skin is more fragile and thinner, this increases the risk of increased erosion due to a decline in skin barrier mechanisms. The injuries caused by the oxygen hood were limited, as it does not directly injure the nasal mucosa. However, these two patients had already incurred injuries when using CPAP. It is not possible to solely ascribe all injuries to the nasal prongs and oxygen hood, as patients who were on High Flow Nasal Cannula (HFNC) and Continuous Positive Airway Pressure (CPAP) for a longer duration had pre-existing injuries in their respective groups. Woodhead *et al*. [15] conducted a study on nasal damage and discovered that infants in the vapotherm group have a reduced likelihood of nasal injuries and exhibited a normal inspection of the nasal mucosa. The researcher examined a group of 30 patients who had been removed from a breathing tube and discovered that the infants in the vapotherm group exhibited superior performance compared to the control group in terms of their nasal mucosa and respiratory score during the examination. In a community-based pilot project conducted by Parmar *et al*. in Madhya Pradesh, the use of nasal prongs did not result in any additional occurrences of nose injuries following staff training and awareness [16]. In a study conducted by Pascual *et al*. [17], it was observed that preterm and low-birth-weight babies had a higher incidence of injuries compared to term babies, which aligns with similar findings. A survey on knowledge, attitude, and practice was done among the nursing staff and junior residents working in the Neonatal Intensive Care Unit (NICU). The majority of nurses were proficient in managing and administering feed through the nasal cannula. These are optimal for utilization by proficient peripheral health care professionals subsequent to receiving training on their usage. The essential factors for achieving success in the management of infants in rural government hospitals in developing nations are training, awareness, and education. Our NICU is a tertiary-level facility, and all nurses undergo comprehensive training, resulting in fewer injuries compared to other research. Periodically, they have been offering nurse education on the topics of NICU nursing care and equipment handling.

Implication of the study for society

This study will improve the knowledge of nursing staff and help them provide quality care to patients admitted to NICU while also addressing the device's cost-effectiveness, selectivity, and feasibility. If we can reduce the number of nasal injuries associated with nasal cannulas, it may show to be one of the best modalities on a large scale, particularly in developing nations, as it is less expensive and more freely accessible. Restricting oxygen consumption reduces the risk of free radical damage injury and ventilatory-associated pneumonia.

Conclusion

The occurrence of desaturation and apneic episodes differs among different devices. Both devices exhibited normal heart rate and blood gas levels without any abnormalities. The nasal cannula resulted in the maximum nasal injuries, predominantly in preterm infants with low birth weight. Nasal cannulas are cost effective and user friendly, thus offering more convenience to nursing staff employed in NICU.

Conflict of interests

No conflict of interests was declared by the authors.

Funding source

The authors did not receive any source of fund.

Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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