Scientific Foundation SPIROSKI, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences. 2023 May 26; 11(B):592-598.
https://doi.org/10.3889/oamjms.2023.11685
eISSN: 1857-9655
Category: *B - Clinical Sciences*
Section: *Pediatrics*

Impact of a Nursing Intervention Bundle of Care on Nasal-CPAP-Related Nasal Injuries in Preterm Infants: A Quality Improvement Initiative

Mohab Mohamed[1], Ahmed Noaman[1], Islam Nour[1,2]*, Hesham Abdel-Hady[1,2]

[1]Departement of Pediatrics, Faculty of Medicine, University of Mansoura, Mansoura, Egypt; [2]Neonatal Intensive Care Unit, Mansoura University Children's Hospital, Mansoura, Egypt

Edited by: Mirko Spiroski
Citation: Mohamed M, Noaman A, Nour I, Abdel-Hady H. Impact of a Nursing Intervention Bundle of Care on Nasal-CPAP-Related Nasal Injuries in Preterm Infants: A Quality Improvement Initiative. Open Access Maced J Med Sci. 2023 May 26; 11(B):592-598. https://doi.org/10.3889/oamjms.2023.11685
Keywords: Continuous positive airway pressure; Preterm; Nasal injury; Quality improvement
***Correspondence:** Islam Nour, Department of Pediatrics, Mansoura University Children's Hospital, Gomhoria Street, Mansoura 35516, Egypt. E-mail: inour2001@gmail.com
Received: 03-May-2023
Revised: 11-May-2023
Accepted: 16-May-2023

Funding: This research did not receive any financial support
Competing Interests: The authors have declared that no competing interests exist

Abstract

AIM: The objective is to assess the effect of the application of a nasal injury prevention bundle on the incidence and severity of nasal-continuous positive airway pressure (nCPAP)-related nasal injuries in preterm infants.

METHODS: We conducted a prospective controlled before-after study in a preterm neonate, <37 weeks gestation, who required nCPAP in the neonatal intensive care unit, at Mansoura University Children's Hospital, between September 2018 through October 2019. After 2 months of nursing staff training, a nasal trauma prevention bundle was implemented. The nursing intervention bundle comprised nasal barrier dressing, regular focused checking for evolving nasal skin injury, and proper application of the CPAP device. nCPAP-related nasal injuries per 1000 days and grading of nasal injury severity were the primary outcomes. Time to onset of nasal injury after initiation of CPAP; duration of nCPAP use, duration of oxygen dependency; incidence of pneumothorax, broncho-pulmonary dysplasia; intraventricular hemorrhage; periventricular leukomalacia; late-onset sepsis; length of hospital stay; and in-hospital mortality were the secondary outcomes.

RESULTS: Data from 62 preterm neonates were analyzed (31 in each group). The nasal trauma prevention bundle of care was associated with reduced nasal injury incidence per 1000 nCPAP-days (140 vs. 148.94, p = 0.03) with improved nasal injury severity staging (p = 0.003) compared to the pre-bundle era. Nasal injury developed earlier in the control group (1 [1–1] vs. 2 [1–3] days, p = 0.002) compared to the intervention group. No statistically significant differences were reported between groups regarding any of the other secondary outcomes. Longer duration of CPAP use (p = 0.009) and lack of bundle application (0.03) were the independent risk factors associated with nCPAP-related nasal injuries in preterm neonates.

CONCLUSION: The implementation of a bundle of nursing interventions is associated with a substantially improved incidence and severity of nasal injuries in preterm infants receiving nCPAP.

Introduction

The undue and extended use of invasive mechanical ventilation in premature neonates is a well-recognized risk factor for lung injury and broncho-pulmonary dysplasia (BPD). A previous meta-analysis reported that early nasal-continuous positive airway pressure (nCPAP) use at birth, compared to routine early intubation, was associated with reduced risk of death or BPD [1]. Thus, noninvasive ventilation use, particularly nCPAP, has been substantially mounted over the last decades as an initial respiratory support tool or post-extubation in preterm infants. One prerequisite for nCPAP success is tight sealing of the nCPAP interface on the infant's nose to minimize leakage and ensure effective airway stenting and alveolar aeration [2]. Yet, excessive pressure exerted by the nCPAP interface upon delicate premature infants' skin with protein-deficient thin epidermal layer, high rates of transdermal water loss, and end vascularization of nasal septum and nostrils might contribute to nasal trauma [3]. Nasal injuries in neonates receiving CPAP have a variable spectrum of severity, ranging from skin hyperemia, blanching, erosions, bleeding, and superficial ulcers up to excoriation, and columella necrosis [4]. Nasal injury may lead to several short and long-term consequences, including pain, discomfort, obstructive apnea, infection, prolonged hospital stays alongside, nostrils disfigurement, and persistent nasal vestibular stenosis for which surgical interventions may be required [5], [6], [7]. Various studies revealed a wide-ranging estimate of nCPAP-related nasal injuries, between 15% and 100% [4], [8], [9]. Risk factors for nasal trauma in premature infants treated by nCPAP have been reported entailing; lower gestational age, smaller birth weight, longer nCPAP duration, binasal prongs, unfitting prongs sizes, incorrect application of nCPAP device, inadequate monitoring of the nasal skin and surrounding tissues, and lack of nursing training [10], [11], [12], [13]. Proposed preventive strategies include nasal barrier dressing, regular focused checking for evolving nasal skin injury, and proper application of the nCPAP device.

We hypothesized that in preterm infants <37 weeks' gestation required nCPAP, implementation of a bundle of care for nasal trauma prevention will reduce the incidence and severity of nCPAP-related nasal injuries and hence reduce nCPAP failure rates. We aimed to study the impact of practicing a care bundle that included the best available evidence for each of the above practices on the nCPAP-related nasal injuries occurrence and severity.

Patients and Methods

Study design and setting

This was a controlled prospective pre-post-intervention study. We enrolled eligible neonates at the neonatal intensive care unit (NICU) of Mansoura University Children's Hospital from September 2018 through October 2019. The study was approved by the Institutional Review Board of the Faculty of Medicine of Mansoura University (reference number: MS.18.03.80). This NICU is a 25-bed, level III, tertiary, teaching unit in the Nile Delta region of Egypt. Our average admission rate is almost 450 infants per/year. For those neonates requiring non-invasive respiratory support, nursing services are provided in a nurse-to-patient ratio of 1 nurse: 3–4 neonates.

We conducted the study in a stepwise approach subdivided into 3 successive phases. Neonates in the pre-bundle era received standard of care practice for 6 months (control group). Subsequently, a 2-month period of nurses training was planned, during which orientation lectures and bedside nursing staff education sessions on how to apply the bundle of care had been run. Afterward, the nasal trauma prevention bundle was implemented in all eligible neonates for the succeeding 6 months (intervention group).

Study population

We included preterm infants delivered <37 weeks' gestation who required nCPAP as either an initial respiratory support modality or post-extubation. Preterm neonates with generalized skin disease (epidermolysis bullosa), preexisting tissue breakdown around interface device, congenital anomalies (e.g., cleft palate, bilateral cleft lip, choanal atresia, and tracheoesophageal fistula), chromosomal anomalies, gastric perforation, intestinal obstruction, and severe cardiovascular instability were excluded.

Study procedures

All recruited neonates throughout the study phases received bubble nCPAP via Fischer and Paykel bubble nCPAP system with a nasal prong (Fischer and Paykel Healthcare Ltd., East Tamaki, Auckland, New Zealand). Bedside nurses checked the nasal cavity and septum for infants receiving nCPAP every day for any pressure injury and documented the degree of injury in a specific form. Infants' noses were regularly photographed daily for reassessment and double-checked by a blinded assessor to assign nasal injury severity stage. Nasal injury grading was identified as per nasal trauma scoring of Fischer *et al*., [4] as follows: (Stage 0) intact non-compromised skin; (Stage I) non-blanching erythema; (Stage II) Superficial erosion; (Stage III) necrosis of full thickness of the skin. Our research team assigned the patient to the most severe stage identified during serial-focused nasal assessment. Adherence to the nursing intervention bundle during the application and care of preterm babies treated by nCPAP had been monitored and ensured each nursing shift by the in-service charge nurse using a six-items checklist during the bundle implementation phase.

Intervention group

The nasal trauma prevention bundle comprised:

1. Frequent evaluation every 8-h shift to determine the continued need for nCPAP therapy [14]
2. Applying protective double hydrocolloid dressing as a barrier between skin and interface device (Duoderm, ConvaTec, Berkshire, England) [15], [16]
3. Use of the appropriately sized interface device, using a sizing guide provided by the manufacturer [14]
4. Visually observe infants every hour to check and maintain interface position [3]
5. Briefly remove the protective barrier and nasal device once during a 12 h-shift to conduct a thorough nasal skin assessment [10]
6. While inserting the prongs into the infant's nares, position the prongs kept in a downward arch position but not in contact with the nasal septum, then secure them to prevent distortion of the nares and compression of the septum. Ensure there is always a minimum 2 mm gap between prongs and septum [3].

Respiratory care pathway

Our NICU policy was to start delivery room nCPAP or nasal intermittent positive pressure ventilation (NIPPV) to all spontaneously breathing preterm neonates with labored respiration after initial resuscitation by the t-piece resuscitator and mask (Neopuff, Fisher and Paykel, Auckland, New Zealand). In the NICU preterm infants continued to receive bubble nCPAP via nasal prongs interface. Selective surfactant instillation by INSURE technique was applied to non-intubated preterm neonates who required FiO2 >0.30 on CPAP pressure of at least 6 cm H2O to maintain

preductal oxygen saturation >90%. nCPAP failure was fulfilled if any of the following criteria had been identified despite optimum nCPAP setting: frequent apnea; worsening work of breathing; or cardiovascular instability; or unsatisfactory blood gases (pH <7.2 with PCO2 ≥55 mmHg or base excess > − 15).

Outcomes

Our primary outcomes were nCPAP- related nasal injuries per 1000 days and severity of the nasal injury. Secondary outcomes included time to onset of nasal injury after initiation of nCPAP; duration of CPAP use, nCPAP failure within 72 h of nCPAP application; duration of oxygen dependency; incidence of pneumothorax; BPD [17]; intraventricular hemorrhage; periventricular leukomalacia; late-onset sepsis; length of hospital stay; and mortality.

Sample size calculation

Previous quality improvement studies reported a 55–45% relative reduction in nasal injury rates after nasal trauma prevention bundle implementation [10], [18]. Our NICU patient's record review over 6 months before the study showed a noticeably higher rate of CPAP-related nasal injuries among preterm infants (90%), compared to (34.7–45.2%) in pre-bundle phases of previous studies [10], [18]. We considered a lower relative reduction of (30%) to estimate the sample size. Therefore, at a power of 80% and alpha of 0.05, a sample size of 25 infants per arm was required to assess our hypothesis. We assumed that 25% of eligible infants will meet exclusion criteria, and hence, 60 neonates should be assessed for eligibility. According to our NICU admission data, we presumed that at 6 months duration for each phase would enable our research team to attain our targeted sample.

Statistical analysis

Data were statistically analyzed using SPSS software version 22.0 (IBM SPSS Statistics, IBM Corporation, Armonk, NY). The Kolmogorov-Smirnov test was applied to check the normality of the distribution for continuous variables. Comparison of numeric and categorical variables between groups was made using the Student t-test or Mann–Whitney U-test and χ^2 test or Fisher's exact test, respectively. The statistical significance threshold was attuned at a p = 0.05. Binary logistic regression was applied to identify risk factors for nasal injury occurrence using the Forward Wald technique. The potential confounders integrated within multivariate analysis included those with a p-value of univariate analysis <0.1, besides clinically relevant variables. We examined the goodness-of-fit of the multivariate regression model using the Hosmer-Lemeshow test. We performed correlation analysis between nasal injury severity grading and each of the presumed determinant variables (gestational age, birth weight, and duration of CPAP) separately using a bivariate Spearman rank-order correlation coefficient test. The strength of the correlation of severity of nasal injury to birth weight and duration of CPAP had been assessed after controlling the effect of each other using partial correlation analysis.

Results

The present study was conducted in 2 time periods, the first phase was before the application of the evidence-based nCPAP nasal trauma prevention bundle between September 2018 and February 2019, and the second phase was after the application of the evidence-based nasal trauma prevention bundle between May 2019 and October 2019. The intervention program training lasted for 2 months between March 2019 and April 2019. Throughout the study phases, a total of 68 neonates received CPAP respiratory support, equating to 372 nCPAP days. Of those, six neonates were excluded for various justifications: chromosomal anomalies (three infants); priori tissue breakdown around interface device (two infants); epidermolysis bullosa (one infant). Sixty-two neonates were followed up and assessed for nCPAP-related nasal injuries, 31 in each phase. The incidence rate of nCPAP-related nasal injuries during the study was 144.97 (CI 0.11–0.19) per 1000 nCPAP-days. The demographic data and baseline clinical characteristics were matched between the control and intervention arms (Table 1).

Table 1: Demographic and baseline characteristics in the study groups

Characteristics	Control group (n = 31)	Intervention group (n = 31)	p-value
Gestational age (weeks)	30.77 ± 2.48	30.81 ± 2.49	0.96
Gestational age <28 weeks	3 (9.7%)	4 (12.9)	1
Birth weight (grams)	1437.42 ± 535.31	1379.19 ± 467.48	0.65
Small for gestational age	8 (25.8%)	7 (22.6%)	0.77
Male gender	18 (58.1%)	14 (45.2%)	0.31
Multiple birth	7 (22.6%)	9 (29%)	0.56
Antenatal steroids	19 (61.3%)	14 (45.2%)	0.2
Premature rupture of membranes	7 (22.6%)	10 (32.3%)	0.39
Caesarean section	28 (90.3%)	24 (77.4%)	0.17
1-min apgar score	5 (5–6)	5 (5–5)	0.94
5-min apgar score	9 (8–10)	9 (8–10)	0.69
Caffeine use	24 (77.4%)	24 (77.4%)	1
Surfactant administration	1 (3.2%)	3 (9.7%)	0.3
Diagnosis			
TTN	5 (16.1%)	5 (16.1%)	1
Pneumonia	5 (16.1%)	2 (6.5%)	0.42
RDS	21 (67.7%)	24 (77.4%)	0.39
Maximum set nCPAP (cmH–O)	5 (5–6)	5 (5–6)	1
Duration of nCPAP (days)	4 (3–8)	4 (2–7)	0.44

Data are expressed as mean ± SD, median (interquartile range) or number (%).

Primary outcomes

Neonates in the intervention group demonstrated a significantly lower incidence of nCPAP-related nasal injuries per 1000 nCPAP-days (140 vs. 148.94, p = 0.03), alongside improved severity of

injuries (p = 0.003) compared to the control group. The frequency of stage III nasal injury declined significantly in the intervention group (9.7% vs. 41.9%, p = 0.003) compared to the control group (Table 2).

Table 2: Nasal injury characteristics

Characteristics	Control Group (n= 31)	Intervention Group (n = 31)	*P*-value
nCPAP-related nasal injuries/1000 days	148.94	140	0.03
Stage of nasal injury			
No injury	2 (6.5%)	9 (29%)	0.003
Stage I	7 (22.6%)	14 (45.2%)	
Stage II	9 (29%)	5 (16.1%)	
Stage III	13 (41.9%)	3 (9.7%)	
Time to onset of nasal injury after initiation of nCPAP (days)*	1 (1-1)	2 (1-3)	0.003

Data are expressed as median (interquartile range)* or number (%).

Secondary outcomes

Neonates who experienced nasal trauma in the intervention group exhibited a significantly longer duration from the time of nCPAP application up to the onset of nasal injury (2 [1–3] vs. 1 [1–1] days p = 0.003) compared with the control group (Table 2). Otherwise, no statistically significant difference was noted pre and post-bundle implementation as regards any of the other secondary outcomes (Table 3). Two infants died before hospital discharge during the intervention phase due to septic shock. Of the five neonates who died in the pre-bundle phase, three had septic shock, one had hypoxemic respiratory failure, and one had surgical necrotizing enterocolitis.

Table 3: Overall NICU course

Characteristics	Control group (n = 31) (%)	Intervention group (n = 31) (%)	p-value
Duration on nCPAP (days)*	4 (3–8)	4 (2–7)	0.44
CPAP failure	6 (19.4)	9 (20)	0.37
Duration of oxygen therapy (days)*	12 (5–23)	7 (4–17)	0.24
Duration of mechanical ventilation (days)*	2 (0–8)	0 (0–5)	0.25
Pneumothorax	4 (12.9)	0	0.11
Bronchopulmonary dysplasia	5 (16.1)	4 (12.9)	1.00
Intraventricular hemorrhage	4 (12.9)	1 (3.2)	0.35
Periventricular leukomalacia	2 (6.5)	1 (3.2)	1.00
Patent ductus arteriosus	0	2 (6.5)	0.49
Necrotizing enterocolitis	1 (3.2)	0	1.00
Late-onset sepsis	12 (38.7)	10 (32.3)	0.59
Length of hospital stay (days)*	35 (14–52)	36 (14–47)	0.96
In-hospital mortality	5 (16.1)	2 (6.5)	0.43

Data are expressed as median (interquartile range)* or number (%).

Risk factors for nCPAP-related nasal injuries

Univariate analysis revealed that duration of nCPAP use, maximum set nCPAP pressure, and admission in the pre-bundle phase were significantly associated with nCPAP-related nasal injuries in preterm neonates. After implementing a multivariate analysis, the duration of nCPAP use and lack of bundle application were the independent predictors of nCPAP-related nasal injuries in preterm neonates (Table 4). The adequacy of the regression model to describe the data was ascertained by Hosmer-Lemeshow test (p = 0.94).

Table 4: Risk factors for nCPAP-related nasal injuries

Risk factors	Univariate analysis		Multivariate analysis	
	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Gestational age	0.77 (0.58–1.03)	0.08	0.96 (0.63–1.45)	0.84
Birth weight	1.00 (0.99–1.00)	0.96		
Duration of nCPAP use	3.93 (1.58–9.74)	0.003	5.15 (1.51–17.56)	0.009
Maximum set nCPAP pressure	3.04 (0.98–9.43)	0.05	0.87 (0.15–5.22)	0.88
Nursing intervention bundle implementation	0.17 (0.03–0.86)	0.03	16.75 (1.35–206.54)	0.03

There was a negative moderate correlation between gestational age and severity of nasal injuries in preterm infants treated by nCPAP ($r = 0.33$, $p = 0.01$), which was not consistent after controlling for nCPAP duration by partial correlation analysis ($r = -0.11$, $p = 0.39$). The duration of nCPAP use was positively related to nasal injury grade, both with and without control of gestational age ([$r = 0.58$, $p < 0.001$] and [$r = 0.7$, $p < 0.001$], respectively). Correlation analysis showed a non-significant correlation between birth weight and severity of nasal injury.

Discussion

We found that applying a nursing bundle of interventions was associated with significant reductions in the rates and severity of nCPAP-related nasal injuries compared with the pre-bundle phase. In our study, the incidence rates of nCPAP-related nasal injuries in the pre-bundle and post-bundle implementation phases were 93.55% and 70.97%, respectively. The previous studies showed varied estimates of nCPAP-related nasal injury occurrence rates in preterm infants ranging from 15% to 100% [8], [9]. These variances may be acknowledged to different nCPAP delivery systems and interfaces used, heterogeneities of enrolled patients regarding gestational age and birth weight, and inconsistent grading for the severity of injury across studies. Among infants with nasal injury throughout our study phases, 16 of 51 neonates (31.37%) had a full-thickness skin loss pattern of injury. This is higher than what was formerly reported in a prospective cohort by Bonfim *et al*., including 70 neonates who received nCPAP, in which 11% of reported injuries were severe. This difference can be explained by a relatively low nurse-to-patient ratio of (1: 3–4) in our cohort, alongside most of the severe nasal injuries (81.25%) that occurred in the pre-bundle phase [19].

We observed that the longer duration of nCPAP and lack of implementation of the nursing intervention bundle were independent risk factors for nasal injury occurrence. Moreover, prolonged duration of nCPAP use and lower gestational age were significantly correlated to nasal injury severity grade. Similarly, in a quality improvement study conducted by Chen *et al*. [10], the duration of nCPAP and the lack of a structured nursing protocol were the most significant risk factors for nasal injury in preterm infants. In a large prospective observational study included 989 neonates

who required nCPAP over 5 years in a tertiary NICU in Switzerland, results showed an increased incidence and grade of severity of nasal injury with lower gestational age, lower birth weight, longer duration of nCPAP use and longer NICU stay [4]. However, the lack of effect of birth weight upon developing nasal injury in our results might be explained by a higher incidence of small for gestational age infants among our cohort (≈25%) with more mature skin and shorter duration of CPAP requirement compared to peers with same birth weight.

One of the key interventions to prevent nCPAP-related nasal injuries in NICU is to release pressure upon the nasal septum by a nasal barrier dressing. In accordance with our results, three RCTs showed that prophylactic application of nasal barrier dressing significantly declined the incidence and severity of the nCPAP-related nasal injury. Xie [20] reported a significantly lower risk of mild–moderate nasal injury in preterm neonates of 28–37 weeks gestation on ventilator nCPAP with the use of a hydrocolloid dressing (2 of 33 [6%] vs. 7 of 32 [21.8%], p = 0.01) compared to paraffin oil, with only one infant in the control group showed severe nasal injury. Similarly, a recent trial reported a lower incidence of nasal injury in preterm infants <32 weeks gestation (mean birth weight of 1338 g) for whom protective nasal hydrocolloid dressing had been applied 15 of 40 (37.5%) vs. 37 of 40 (92.5%; p < 0.001) compared to the control group. Yet, most of the reported nasal injuries were mild to moderate, and no statistically significant difference had been noted between severe injury occurrence rates among groups (3 of 40 and 5 of 40 in the intervention and control group, respectively) [15]. Moreover, Imbulana *et al*. [21] conducted a controlled trial to assess the efficacy of hydrocolloid nasal barrier dressing in more immature infants delivered <30 weeks' gestation (mean gestational age 27.4 weeks) while using nasal prongs for nCPAP or NIPPV. The results showed a significant decline of mild nasal injury occurrence rates in the barrier group compared with the no barrier group (34.0% vs. 56.4%, p = 0.02) as assessed by the bedside nurse with none of the enrolled infants showing full-thickness skin loss pattern of injury. However, a significant improvement was not evident in subgroup analyses of neonates born <28 weeks' gestation or those double-checked by review of nasal photographs, which was attributed by the authors to premature termination of the trial due to slow recruitment rate. Therefore, solid evidence about the efficacy of hydrocolloid dressing to prevent severe forms of nCPAP-related nasal injuries and its effectiveness among extremely preterm infants is still lacking.

In agreement with our findings, previous quality improvement studies reported that applying nursing intervention bundles was associated with declining rates of nCPAP-related nasal injuries in preterm infants. The common core concept of the intervention bundle of these studies was focused training of nursing staff for proper nCPAP application, nasal barrier dressing, and scheduled assessment for nasal injuries. Chen *et al*. [10] observed a lower risk of nasal hyperemia (7.4%) among a subgroup of infants with a birth weight of ≥1000 g after the implementation of nursing protocol compared with (26.9%) in the pre-protocol group (p = 0.03), but not for bleeding or ulceration (only one case showed ulcer within the whole cohort). Similarly, Mariam and Buddhavarapu conducted a Plan-Do-Study-Act model for quality improvement in a level 3 NICU with the average patient to nurse ratio1:2, which revealed significantly improved bubble nCPAP-related nasal injuries rates from (91/1000 nCPAP days) in the pre-intervention phase to (8/1000 nCPAP days) after bundle implementation, with none of the reported injuries ranked as severe. Authors attributed the declining rate of nasal injuries to a concomitant upsurge of nursing compliance with fixing nCPAP as per recommendation from 35% to 95%. However, the lack of severe nasal injuries among the whole cohort should be taken cautiously as the net score for each patient's injury was a sum of individual points injury score, which means that an infant might have tissue loss at a single point and scored as mild [22]. Milligan and Goldstein from the USA assessed the efficacy of the implementation of an evidence-based non-invasive respiratory support bundle in the NICU to decrease nasal injury rates. They found that bundle implementation was associated with declining in nasal injury incidence to (18.9%) compared to (34.7%) pre-bundle; however, it was not statistically significant, p = 0.086).

We observed that the application of the nursing intervention bundle was associated with a significantly longer interval between the commencement of nCPAP therapy and the onset of nasal injury compared to the pre-bundle group. By our results, Rezaei *et al*. [15] noted that nasal dressing barrier use compared with no barrier was associated with a more deferred onset of skin breakdown development, with most injuries in the no barrier group occurring 6–12 h compared to 18–24 h in the intervention group after nCPAP (p < 0.001). On the other hand, the aforementioned study by Xie reported a longer time interval between the initiation of nCPAP and onset of mild and moderate nasal injuries (range of [1–5 days] vs. [3–5 days]) in the control and the hydrocolloid nasal barrier dressing group; respectively]. A more delayed onset of injury may be explained by the larger average gestational age of enrolled infants (32.6 weeks) in comparison to (30.79) in our study.

To our knowledge, this is the first study to report a significant decline of severe form nasal injuries in preterm infants treated by nCPAP after nursing intervention bundle implementation. Moreover, all infants in our cohort had been assessed for nasal injury staging by nasal photograph review by an assessor blinded to group allocation. We acknowledge several limitations of our study. It was conducted as a single-center study in a relatively crowded unit with a low

patient-to-nurse ratio, alongside, only bubble nCPAP with a single interface type applied to all included infants. In addition, being an open-label, cohort study with a relatively small sample size.

Conclusion

The implementation of a nursing nCPAP nasal trauma prevention bundle is associated with a significant decline in CPAP-related nasal injuries and significantly lower rates of full-thickness skin loss injuries in preterm neonates.

Authors' Contributions

Dr. Abdel-Hady and Dr. Noaman formulated the hypothesis, designed the study proposal, supervised data collection, and critically appraised the initial manuscript draft; Dr. Mohamed contributed in study design, recruited patients, collected the data, and approved the final manuscript; Dr. Nour shared in study design, ran the statistical analysis and drafted the initial manuscript and amended it according to other authors' reviews; All authors approved the final manuscript as submitted and assent to all aspects of the work.

Acknowledgment

We would like to thank the families and infants who participated in the study, and the nursing staff of the NICU at Mansoura University Children's Hospital.

References

1. Schmölzer GM, Kumar M, Pichler G, Aziz K, O'Reilly M, Cheung PY. Non-invasive versus invasive respiratory support in preterm infants at birth: Systematic review and meta-analysis. BMJ. 2013;347:f5980. https://doi.org/10.1136/bmj.f5980
PMid:24136633
2. Falk M, Gunnarsdottir K, Baldursdottir S, Donaldsson S, Jonsson B, Drevhammar T. Interface leakage during neonatal CPAP treatment: A randomised, cross-over trial. Arch Dis Child Fetal Neonatal Ed 2021;106(6):663-7. https://doi.org/10.1136/archdischild-2021-321579
PMid:33963004
3. McCoskey L. Nursing care guidelines for prevention of nasal breakdown in neonates receiving nasal CPAP. Adv Neonatal Care. 2008;8(2):116-24. https://doi.org/10.1097/01.ANC.0000317260.99072.ae
PMid:18418209
4. Fischer C, Bertelle V, Hohlfeld J, Forcada-Guex M, Stadelmann-Diaw C, Tolsa JF. Nasal trauma due to continuous positive airway pressure in neonates. Arch Dis Child Fetal Neonatal Ed. 2010;95(6):F447-51. https://doi.org/10.1136/adc.2009.179416
PMid:20584802
5. Li Y, Sepulveda A, Buchanan EP. Late presenting nasal deformities after nasal continuous positive airway pressure injury: 33-year experience. J Plast Reconstr Aesthetic Surg. 2015;68(3):339-43. https://doi.org/10.1016/j.bjps.2014.10.036
6. DeRowe A, Landsberg R, Fishman G, Halperin D, Fliss D. Neonatal iatrogenic nasal obstruction. Int J Pediatr Otorhinolaryngol. 2004;68(5):613-7. https://doi.org/10.1016/j.ijporl.2003.12.012
7. Aly H, Hammad T, Ozen M, Sandhu I, Taylor C, Olaode A, *et al*. Nasal colonization among premature infants treated with nasal continuous positive airway pressure. Am J Perinatol. 2011;28(4):315-20. https://doi.org/10.1055/s-0030-1268711
PMid:21117015
8. Günlemez A, Isken T, Gökalp AS, Türker G, Arisoy EA. Effect of silicon gel sheeting in nasal injury associated with nasal CPAP in preterm infants. Indian Pediatr. 2010;47(3):265-7. https://doi.org/10.1007/s13312-010-0047-9
PMid:19430064
9. Do Nascimento RM, Ferreira AL, Coutinho AC, Veríssimo RC. The frequency of nasal injury in newborns due to the use of continuous positive airway pressure with prongs. Rev Lat Am Enfermagem. 2009;17(4):489-94. https://doi.org/10.1590/s0104-11692009000400009
PMid:19820855
10. Chen CY, Chou AK, Chen YL, Chou HC, Tsao PN, Hsieh WS. Quality improvement of nasal continuous positive airway pressure therapy in neonatal intensive care unit. Pediatr Neonatol. 2017;58(3):229-35. https://doi.org/10.1016/j.pedneo.2016.04.005
PMid:27666491
11. Naha N, Pournami F, Prabhakar J, Jain N. Nasal injury with continuous positive airway pressure: Need for "Privileging" nursing staff. Indian J Pediatr. 2019;86(7):595-8. https://doi.org/10.1007/s12098-019-02960-1
PMid:31020593
12. Yong SC, Chen SJ, Boo NY. Incidence of nasal trauma associated with nasal prong versus nasal mask during continuous positive airway pressure treatment in very low birthweight infants: A randomised control study. Arch Dis Child Fetal Neonatal Ed. 2005;90(6):F480-3. https://doi.org/10.1136/adc.2004.069351
PMid:15941825
13. Shanmugananda K, Rawal J. Nasal trauma due to nasal continuous positive airway pressure in newborns. Arch Dis Child Fetal Neonatal Ed. 2007;92(1):F18. https://doi.org/10.1136/adc.2006.095034
PMid:17185425
14. Bonner KM, Mainous RO. The nursing care of the infant receiving bubble CPAP therapy. Adv Neonatal Care. 2008;8(2):78-95; quiz 96-7. https://doi.org/10.1097/01.ANC.0000317256.76201.7
PMid:18418205
15. Rezaei P, Jafari-Mianaei S, Sadeghnia A, Heidari Z. Protective dressings, injury, and device failure in preterm infants receiving nasal continuous positive airway pressure: A randomized controlled trial. Adv Skin Wound Care. 2021;34(9):1-6. https://doi.org/10.1097/01.ASW.0000767344.37591.b6
PMid:34415257
16. Imbulana DI, Manley BJ, Dawson JA, Davis PG, Owen LS. Nasal injury in preterm infants receiving non-invasive

respiratory support: A systematic review. Arch Dis Child Fetal Neonatal Ed. 2018;103(1):F29-35. https://doi.org/10.1136/archdischild-2017-313418

PMid:28970314

17. Jobe AH, Bancalari E. Bronchopulmonary dysplasia. Am J Respir Crit Care Med. 2001;163(7):1723-9. https://doi.org/10.1164/ajrccm.163.7.2011060

PMid:11401896

18. Milligan PS, Goldstein MR. Implementation of an evidence-based non-invasive respiratory support (NIRS) bundle in the NICU to decrease nasal injury complications. J Neonatal Nurs. 2017;23(2):89-98. https://doi.org/10.1016/j.jnn.2016.05.003

19. Bonfim SF, de Vasconcelos MG, de Sousa NF, da Silva DV, Leal LP. Nasal septum injury in preterm infants using nasal prongs. Rev Lat Am Enfermagem. 2014;22(5):826-33. http://doi.org/10.1590/0104-1169.3451.2486

PMid:25493679

20. Xie L. Hydrocolloid dressing in preventing nasal trauma secondary to nasal continuous positive airway pressure in preterm infants. World J Emerg Med. 2014;5(3):218-22. https://doi.org/10.5847/wjem.j.issn.1920-8642.2014.03.011

PMid:25225588

21. Imbulana DI, Owen LS, Dawson JA, Bailey JL, Davis PG, Manley BJ. A randomized controlled trial of a barrier dressing to reduce nasal injury in preterm infants receiving binasal noninvasive respiratory support. J Pediatr. 2018;201:34-9.e3. https://doi.org/10.1016/j.jpeds.2018.05.026

PMid:30251638

22. Mariam S, Buddhavarapu S. Impact of systematic training and CPAP checklist in the prevention of NCPAP related nasal injuries in neonates- a quality improvement study. Indian J Pediat. 2020;87(4):256-61. https://doi.org/10.1007/s12098-019-03146-5

PMid:31942677