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ContinuousPositive Airway Pressure and Nasal Trauma in Neonates: a descriptive prospective study

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Abstract: Objectives:This study aimedto evaluate the frequency and severity of nasal trauma secondary to nasal continuous positive airway pressure (NCPAP) in neonates.
***Methods:** This is a prospective observational study carried out in the Neonatal Care Unit (NCU) of Baghdad teaching hospital,maternity ward, Medical City, Baghdad, Iraq. The study included newborns that underwent NCPAP with prongs on admission and those receiving NCPAP after weaning from ventilation, from 1st March, 2014 - 1st July, 2014. Patients' noses were monitored from the first day of NCPAP treatment until its weaning. Nasal trauma was reported into three stages: (I) persistent erythema; (II) superficial ulceration; and (III) necrosis.*
***Results:**Two hundred ten newborns (130 males, 80 females) were enrolled.Mean gestational age was 33±3.5 weeks (SD), mean birth weight 2044 ±765g (SD). All patients had some degree of nasal trauma with stage I, II and III in 93 (44.3%), 52 (24.8%) and 65 (31.0%) patients, respectively. Frequency and severity of trauma were inversely correlated with gestational age and birth weight. Severe lesion(stageIII)was significantly and directly positively correlated with the total duration on NCPAP (P<0.00). The risk of nasal trauma was greater in neonates <32 weeks of gestational age, weighing <1500 g at birth,requiringlarger nasal prong size or smaller head caps and/or requiringNCPAP>2 days.*
***Conclusions:** Nasal trauma is a frequent complication of NCPAP, especially in smaller preterm babies and in babies requiring larger nasal prongs or longer NCPAP application.*
***Keywords:**Continuous positive airway pressure, nasal trauma, neonates*

I. Introduction

Continuous Positive Airway Pressure (CPAP) has provided an exciting therapy for treating respiratory distress (RDS) in the newborn. Its primary function is to establish/maintain open airways. The circuit is structured such that a continuous flow of humidified oxygen in combination with other compressed gases is delivered to the infants often with nasal prongs or masks[(1)].

The CPAP goal is accomplished by supplying about 4 – 8 cmH_2O positive airway pressure into infant`s airway [2].To apply this pressure system, three component are essential: continuous flow of a heated and humidified gas mixture (compressed air and oxygen); a system connecting the device to the patient`s airway such as facial masks, nasal prongs, nasopharyngeal or endotracheal tubes and a mechanism of positive pressure generation in thesystem [3-4].

A nasal prong is the most common deviceused because it is a less invasive way of supplying CPAP [3], typically called nasal CPAP or NCPAP.It is available in different sizes and usually made of light flexible material [4]. Despite its advantage, this device can harm the nostrils and cause discomfort and disfiguration in the long term [5].

The local pressure of NCPAP devices may lead to decubitus lesions in the newborn due to its cutaneous vulnerability and anatomical factors such as end - vascularization of the columella and nostrils [6].In addition,nasal trauma represents a source of discomfort for patient, possible site of infection and a risk of long term functional or cosmetic sequelae [7-8].

Research classifies nasal injuries caused by the use of prongs in three stages: mild, moderate and severe: The mild stage (I) is described as redness or nasal hyperemia; the moderate (II) presents bleeding injuries and the severe stage (III) refers to injuries with necrosis [9].

Local irritation and trauma to the nasal septum may occur due to misalignment or improper fixation of nasal prongs [10]. Breakdown and erosion low on the septum at the base of the philtrum can occur when using nasal masks or prongs, and columella necrosis can occur after only short periods of receiving NCPAP. Nasal

snubbing and circumferential distortion (widening) of the nares can be caused by nasal prongs, especially if NCPAP is being used for more than just a few days. Inadequate humidification can lead to nasal mucosal damage [11].

In Baghdad, Iraq, a few studiesof the use of CPAP in neonates but to the best of our knowledge, no study about nasal trauma after CPAP in neonates in Baghdad has been published.[12] Thisobservational prospective study aimed to fill this research gap by determiningthe frequency and severity of nasal trauma secondary to NCPAPwith prongs in neonatal care unit in maternity ward of Baghdad teaching hospital.

II. Methods

This descriptive prospective study was carried out in the Neonatal Care Unit (NCU) of Baghdad teaching hospital maternity ward.The Ethical committee of the hospital approved this study.One of the research team(RYR) observed the neonates withtheresponsible nurses help to observe nasal injuries without touching them.

The study included newborns that underwent NCPAP with prongs on admission and those receiving NCPAP after weaning from ventilation, from 1st March, 2014 - 1st July, 2014. The sample size was 210 newborns. They were prospectively observed to detect nasal trauma from the first day of NCPAP treatment until its weaning.

Standard policy in our NCU is to promote the routine use of NCPAP within minutes after birth for all newborns with respiratory distress regardless of etiology. Pressure of 4 - 6 cmH_2O is maintained and oxygen is adjusted to keep PaO2 >50mm Hg. Endotracheal intubation and mechanical ventilation are considered when NCPAP is not sufficient to achieve a satisfactory PaO2 while breathing 80–100% O2 and/or lower the PaCO2 <65 mm Hg, or to relieve marked retractions or frequent apneas. Weaning NCPAP is considered when the tachypnea and retractions become minimal or have disappeared and when there is no longer need for supplemental oxygen. NCPAP is reintroduced when the infant has tachypnea >70/min, deep retractions or frequent episodes of apnea and bradycardia.

Throughout the study period, the same NCPAP system was used (Fisher and PayKel Bubble-CPAP system BC 161, New Zealand, UK). This system involves a source of gas flow (6-8 L /min), air oxygen blender, humidifier (MR85,Fisher& Paykel Health Care, New Zealand) and respiratory circuit. Nasal tubing (Flexi trunk) and nasal prongs and masks were alternativelyusedto deliver CPAP. A transparent template is available from Fisher-Paykel to suggest appropriate nasal prong-size according to the circumference of the nasal cavity and the width of the septumwas used to determine the size of prongs needed for each infant. Generally using these guidelines: neonates <1000 g required 35/20; neonates 1000 – 2000 g required 40/30, and neonates 1500 – 2499 g required 50/40. The prongs were positioned at least 2 mm from the septum to avoid pressure necrosisand were secured using a head cap and Velcro felt.[13]

Infant were positioned supine, prone or on their sides generallyflexed.Nursing care included gentle massages of pressure points of nasal devices every 2–4 hrwithout any ointment. When a nasal trauma was noted, an ointment (sodium fusidate 20 mg) was applied with massages. In case of persistent trauma or increased in severity, a piece of cotton was placed between pressure points and NCPAP devices.

To collect and establish lesions caused by the NCPAP prongs, the stage of lesions, use of protection, number and type of prongs used, the nurse and researcher took the prongs out of newborns' nostrils briefly, checked their nostrils and immediately replace the prongs. Because inspection was external and not instrumented, it waspossible to miss isolated internal trauma of the nostrils. Other complimentary data were extracted from the neonatology charts, medical evolution records and nursing files.

There is currently no widely recognized classification available to describe the severity of nasal trauma secondary to NCPAP in neonates. We therefore classified trauma based on the standardized classification of decubitus lesions from the US National Pressure Ulcer Advisory Panel (NPUAP) [14,15].Stage I: erythema not blanching, on an otherwise intact skin. Stage II: superficial ulcer or erosion, with partial thickness skin loss.
Stage III: necrosis, with full thickness skin loss. When a patient presented with a nasal trauma of different stages, only the most severe stage was used.

Statistical analysis: Data were analyzed by using the statistical package for social sciences (SPSS) version 21. Descriptive statistics were presented as mean, standard deviation (SD), frequencies (NO.) and percentages (%). Chi square testing was used to assess the significance of the association between categorical variables (frequencies). Student's t test was used to compare two means while ANOVA test (analysis of variances) was used to compare three means. Level of significance (p. value) <0.05 was considered significant. Finally results and findings were presented in tables and figures with explanatory paragraphs.

III. Results

A total of 210 neonates were enrolled in this study.The mean gestational age was 33.2 ± 3.5 weeks (range: 25 – 40). Sixteen neonates (7.6%) had gestational age of < 28 weeks, 69 (32.9%) were 28 – 32 weeks, 81 (38.6%) were 33 – 36 weeks and 44 (21%) were ≥ 37 weeks.One-Thirty neonates (61.9%) were males versus 80 (38.1%) females. Birth weight ranged from 650 to 3900 grams with a mean of 2044 ± 765 grams. From these,14 neonates (6.7%) weighed < 1000 gm, 121 (57.6%) weighed 1000 – 2499 gm, and 75 (35.7%) weighed ≥ 2500 gm.

Respiratory distress syndrome (RDS) was the most frequent indication for NCPAP occurring in 144 (68.6%) while 62 (29.5%) had transient tachypnea of the newborn (TTN), and only 2 had apnea of prematurity and 2 needed respiratory support post extubation.All patients had some degree of nasal trauma with stage I, II and III in 93 (44.3%), 52 (24.8%) and 65 (31.0%) patients, respectively.

The cross-tabulation (Table 1) between gestational age categories and the lesion stage, and also the comparison of mean gestational age and stage of the lesion revealed an inverse (negative) but significant correlation. Additonally, neonates who had a lower gestational age had significantly more severe lesions. Furthermore the mean gestational age of those neonates with stage 1(mild) lesions was significantly higher than those with moderate (stage II) and/or severe lesions (stage III) (Fig.1).

There was a significant inverse correlation between the birth weight and stage of the lesion,both compared as categories or mean along the stages, P<0.001, (Table 2& Fig .2).

There was a direct (positive) significant correlation between the lesion stage and size of nasal piece (P=0.023). A significant inverse correlation had been found between severity of lesion and the size of head cap (P<0.001).(Table3)

There was no statistically significant association between the age CPAP was applied and the lesion stages (P=0.32). Neonates with moderate lesion had the higher mean age when put on CPAP than those with stage I and stage III, respectively, (P<0.001).

A significant association was found between the age when injury developed and the lesion stages.

The lesion stage was significantly and directly (positive correlation) correlated with the total duration on CPAP, with severe lesion (stage III)requiring longer duration of NCPAP, (P<0.00), (Table 4 and Fig.3).

IV. Discussion

Nasal CPAP is the preferred means of ventilatory support for most neonates with respiratory distress. Complications can thus be expected and should be looked for and quantified whenever possible. To date, there are limited reports in the literature regarding intranasal complications [14].

Comparisons between published studies are difficult because of highly variable descriptions and definitions of nasal trauma, which can differ in severity from limited local redness to full necrosis. We proposed a simple and reproducible classification system including three stages adapted from the general classification of the US NPUAP [14, 15].

The most frequent indication of NCPAP in our study was RDS (68.6%) followed by TTN (29.5%). These result differ from those of Fischer et al[16], which reveal TTN in the majority of cases (43%), followed by,aspiration syndrome (30%) and RDS (9%). This may be due to high rate of premature deliveries, elective cesarean section delivery. The difference in etiologies might effect the rates of different stages of nasal trauma between locations but this would need require further studies.

The nasal trauma secondary to NCPAP was a frequent complication in our neonates. Stage I lesions were seen in (44.3%), (stage II) in (24.8%) and (stage III) in (31.0%). These result differ from Nascimento et al [17], who found stage I in 79.6%, stage II in 19.7% and stage III in 0.7% of their neonates.

We postulate that the formation of nasal lesions may be related to health professionals inappropriately fixing the prongs into the newborns' nostrils. More severe damage would be expected if the entire prongs are inserted such that the device is in direct contact with the columella. In this study, no nasal protection was used, while it was used in (96.6%) of patients in the study by Nascimento et al [17].

More severe lesions would be expected without the use of protection. Addtionally, inappropriately small prongs may move more inside the nostrils causing more damage to the septum.

Because of our limited supply of prongs, we could not use new prongs each time therefore, we had to disinfect our prongs between use Addtionally, we did not exchange and sterilization the system every two days as recommended in the literature . Routine disinfection of prongs likely leds to detoriation of the material making it less flexible, a potential risk factor for the development of nasal lesions [18].

There was an inverse (negative) significant correlation between mean gestational age and the lesion stage. As expected, neonates with younger gestational age had the more severe lesion, as also seen by Fischer et al [16] and Alsop et al [19], who found that the frequency and severity of nasal trauma increased with lower gestational age (> 90% in neonate <32 week of gestational age).

As also expected their was a significant inverse correlation between the birth weight and lesion stage, in agreement with Fischer et al[16]and Robertson et al [20], who estimated relative risk was significantly higher in patient weighing < 1500 (25%), (20%) respectively.

There was a direct (positive) significant correlation between the lesion stage and size of nasal piece (P=0.023), as also found by Nascimento et al [17]. Our limited choice of prong sizes may led to more nasal lesions. The ideal prong size reported in the literature is one not so large that it distends the nostrils and not so small that it allows extra space between the prong and nostrils [18]. Even though lesions are still observed with the correct size of prongs, they are present in a smaller proportion.[21]

In contrast toNascimento et al [17], we found a significant but inverse correlation between severity of lesion and the size of head cap (P<0.001). One explanation maybe that caps too large for the neonates head may led to increase tube movement and thus trauma to the nose.Thus, it is advisable to ensure adequate cap sizes limiting pressure on the nostrils to the minimum[20]. Importantly, when the neonate is premature, low birth weight and/or has a small head circumference he need small head cup and will likely need more time on CPAP, resulting in increase risk factors for development of nasal injury. In the absence of caps, bandages were fixed around the head with patches with the same function immobilizing the prongs also possibly affecting the severity of the nasal lesions. As much as possible, NCPAP tubing should be positioned on the hat following the manufacturer's recommendations without pressure on the skin, pull on the nasal septum, ensuring the absence of a brow furrow, (indicative of excessive pressure on the nasal septum)[10].

The lesion stage was significantly and directly (positive correlation) correlated with the total duration on CPAP with severe lesion (stage III) associated withthe longer duration. This was also found by several other researhers including Fischer et al [16], Yong et al[21], Nascimento et al [17] and Squires and Hyndman [22],who concluded the frequency of lesions with the use of CPAP with prongs after a minimum period of two days was 100% and time was a risk factor for the development of lesions[17].

V. Conclusions

Nasal trauma is a frequent complication of NCPAP, especially in preterm neonates with RDS. Risk factors for advanced stages of nasal lesions includes lower gestational age and birth weight, larger size of nasal prongs, smaller size of head caps and longer duration on CPAP.

We recommend paying special attention when using NCPAP in preterm and low birth weight neonates especially those with RDS**.** Addtionally we recommend ensuring application of appropriate size of prongs and caps; particularly avoiding the use of prongs and caps which are too small. Finally, when possible shorten the total duration of NCPAP use**.**

Declaration of interest: The authors report no declarations of interest

Author's contributions: NNH participated in the study design, sequence alignment and drafting and finalization of the manuscript and submission to the journal. RYR participated in the study design, data collection, sequence alignment and drafting and finalization of the manuscript. All authors read and approved the final manuscript.

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Table 1: Correlation between gestational age and lesion stage (severity)

Gestational Age (weeks)	Total No.	Lesion stage						P
		Stage I (mild)		Stage II (moderate)		Stage III (severe)		
		no.	%	no.	%	no.	%	
< 28	16	3	18.8	0	0.0	13	81.3	**0.001sig**
28 – 32	69	11	15.9	23	33.3	35	50.7	
33 – 36	81	51	63.0	21	25.9	9	11.1	
≥ 37	28	28	63.6	8	18.2	8	18.2	
Total	210	93	44.3	52	24.8	65	31.0	
Mean ± SD		34.9 ± 3.3		33.3 ± 2.8		30.6 ± 3.5		**0.001sig**

Table 2: Correlation between lesion stage and birth weight (N=210)

Birth weight (gm)	Total No.	Lesion stage						P
		Stage I (mild)		Stage II (moderate)		Stage III (severe)		
		no.	%	no.	%	no.	%	
< 1000	**14**	3	21.4	1	7.1	10	71.4	**<0.001sig**
1000 - 2499	**121**	38	31.4	36	29.8	47	38.8	
≥ 2500	**75**	52	69.3	15	20.0	8	10.7	
Total	**210**	93	44.3	52	24.8	65	31.0	
Mean ± SD		2422 ± 688		2010 ± 680		1530 ± 622		**<0.001sig**

Table 3: Correlation between lesion stages and size of nasal piece and head cap

Variable	Total No.	Lesion stage						P
		Stage I (mild)		Stage II (moderate)		Stage III (severe)		
		no.	%	no.	%	no.	%	
Size of nasal piece								
35 - 20	**150**	57	38.0	41	27.3	52	34.7	**0.023 sig**
40 - 30	**24**	14	58.3	5	20.8	5	20.8	
45 - 40	**2**	0	0.0	0	0.0	2	100.0	
50 - 40	**34**	22	64.7	6	17.6	6	17.6	
Size of head cap								
17- 22	**24**	5	20.8	2	8.3	17	70.8	**<0.001 sig**
22- 25	**95**	26	27.4	33	34.7	36	37.9	
25- 29	**7**	2	28.6	2	28.6	3	42.9	
29- 36	**84**	60	71.4	15	17.9	9	10.7	

Table 4: Distribution of mean age of put on CPAP, age at injury developed and duration on CPAP according to the lesion stages

Variable	Lesion stage			P
	Stage I (mild)	Stage II (moderate)	Stage III (severe)	
Age when put on CPAP (hrs.)	24 ± 1.1	28.6± 12.8	26.4 ± 12.6	**0.32NS**
Age when injury developed (hrs.)	35.7 ± 13.2	48.2 ± 14.6	43.5 ± 11.7	**<0.001**
Total duration on CPAP (hrs.)	50.0 ± 14.7	96.4 ± 32.5	137.3 ± 36.3	**<0.001**

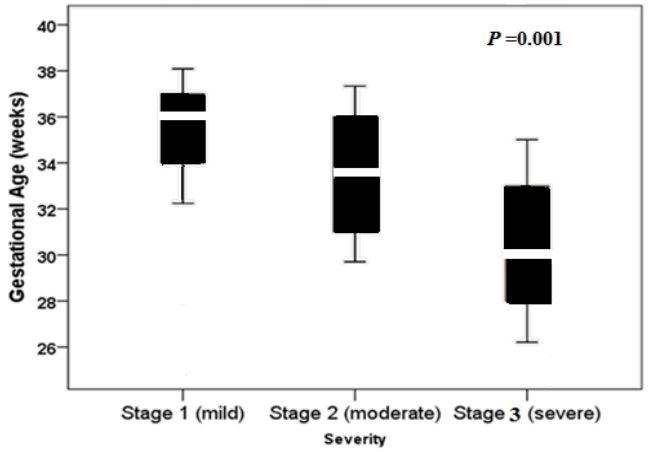

Figure1: Comparison of mean gestational age according to lesion stage

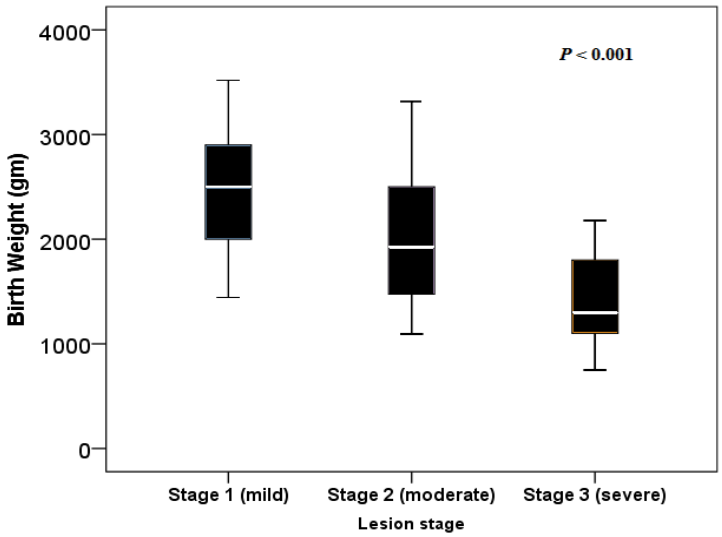

Figure 2: Comparison of mean birth weight according to lesion stage

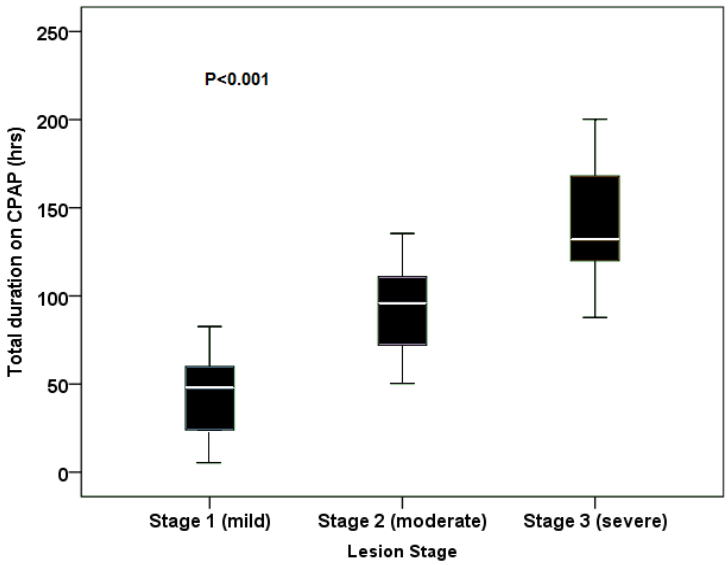

Figure 3: Comparison of mean duration on CPAP according to lesion stages.