



## Hydrocolloids reduce nasal injuries in infants receiving CPAP: a systematic review

Siti Nur Ngaisah<sup>1\*</sup>, Yeni Rustinah<sup>1</sup>

<sup>1</sup> Departement of Nursing Prediatric, Universitas Indonesia,  
Jalan Margonda Raya, Pondok Cina, Kecamatan Beji, Kota Depok, Jawa Barat

\*Corresponding author: [siti.nur03@ui.ac.id](mailto:siti.nur03@ui.ac.id)

### ABSTRAK

**Latar Belakang:** CPAP merupakan manajemen oksigenasi standar dalam penanganan kegawatdaruratan pernapasan pada bayi. Prinsip kerja CPAP adalah mempertahankan kapasitas sisa fungsional paru, membantu pertukaran gas, mengembangkan alveoli dan mencegah atelektasis. Manfaat lain dari penggunaan CPAP seperti meminimalisasi potensi trauma terhadap penggunaan ventilasi mekanis, mengurangi kebutuhan perawatan di ruang intensif dan mengurangi biaya perawatan. Meskipun demikian, belum ada kesepakatan mengenai kapan dan bagaimana penyapihan terhadap bayi yang stabil dari CPAP. Pemakaian CPAP dalam jangka panjang memiliki efek samping seperti terjadinya aspirasi, ketidakstabilan hemodinamik, serta mukosa hidung yang kering. Efek lain yang merugikan dari penggunaan CPAP adalah terjadinya skin breakdown atau cedera pada kulit sekitar hidung dan pangkal hidung akibat tekanan aliran yang tinggi berupa kemerahan sampai terjadinya kematian jaringan yang dapat menyebabkan nyeri. 13,1% kerusakan kulit terjadi pada stadium I dan 1,3% berada pada stadium II. Nyeri yang di timbulkan oleh cedera hidung akan membuat bayi menangis dan meningkatkan risiko perdarahan intraventrikuler. Salah satu cara mencegah cedera hidung ialah dengan menggunakan hidrokoloid sebagai skin barrier. Skin barrier merupakan lapisan pelindung antara epidermis dan sungkup yang dapat mengurangi risiko Medical adhesive related skin injury (MARSI), serta melindungi kulit dari cairan tubuh dan eksudat. Kecermatan dalam melakukan pemantauan dan evaluasi berkelanjutan sangat membantu mencegah komplikasi dan mempertahankan kenyamanan bayi

**Tujuan:** mengetahui manfaat balutan hidrokoloid terhadap cedera hidung dan kenyamanan pada bayi yang menggunakan CPAP.

**Metode:** Tinjauan literatur; penelusuran artikel tinjauan literatur melibatkan beberapa database online yaitu Sciene Direct, Pubmed, Proquest, and Google Scholar tahun 2014 - 2020 berdasarkan kerangka PICO dan di fokuskan dengan menggunakan PRISMA. Partisipan dalam penelitian terdiri dari 50 anak, satu lansia, 59 staf medis dan 1159 bayi.

**Hasil:** Didapatkan 9 artikel yang sesuai dengan tujuan penelusuran. Terdapat enam artikel yang menggunakan partisipan bayi; satu artikel dengan partisipan anak; satu artikel dengan partisipan bayi dan lansia serta satu artikel menggunakan partisipan staf medis dan bayi. Pada analisis ditemukan tiga tema utama yaitu: faktor penyebab cedera hidung meliputi usia gestasi, berat badan; durasi penggunaan CPAP dan penyakit bayi; penggunaan interface mencakup sungkup, prong dan rotasi; penggunaan barrier seperti kassa lembab dan hidrokoloid.

**Kesimpulan:** cedera hidung dapat di cegah dengan melakukan pemilihan interface yang tepat serta pemberian hidrokoloid sebagai barrier.

**KATA KUNCI:** bayi; cedera hidung; cpap; hidrokoloid

## ABSTRACT

**Background:** CPAP is the standard oxygenation management in the respiratory emergencies in infants. The principle of CPAP is to maintain the functional residual capacity of the lung, assist gas exchange, expand the alveoli and prevent atelectasis. Other benefits of CPAP are minimizing the potential for trauma to mechanical ventilation, reducing the need for intensive care and reducing costs. However, there is no agreement on when and how to wean stable infants from CPAP. Long-term use of CPAP has side effects such as aspiration, hemodynamic instability, and dry nasal mucosa. Another adverse effect of using CPAP is the occurrence of skin breakdown or injury on skin and nose bridge due high flow pressure such as redness or necrose which can cause pain. 13.1% of skin damage occurred in stage I and 1.3% were in stage II. Pain caused by a nasal injury will make the baby cry and increase the risk of intraventricular hemorrhage. One way to prevent nasal injury is using hydrocolloid as a skin barrier. The skin barrier is a protective layer between the epidermis and the mask that can reduce the risk of Medical adhesive related skin injury (MARS), as well as protect the skin from body fluids and exudates. Accuracy in carrying out continuous monitoring and evaluation is very helpful in preventing complications and maintaining baby comfort

**Objectives:** Determined benefits of hydrocolloid dressing on nasal injury and comforting infants with CPAP

**Methods:** Systematic review, the articles search involved several online databases such as Sciene Direct, Pubmed, Proquest, and Google Scholar at 2014 - 2020 based on the PICO framework and focused on using PRISMA. Participants in the study consisted of 50 children, one elderly person, 59 medical staff and 1159 infants.

**Results:** 9 articles found according to the criteria. There are six articles using infant participants; one article with child participants; one article with infant and elderly participants and one article using medical staff and infant participants. The analysis showing three main themes: risk factors such as gestational age, body weight, duration of using CPAP and infant illness; interface usage includes masking, prong and rotation; use of barriers such as moist gauze and hydrocolloids

**Conclusions:** nasal injury can be prevented by selecting the right interface and administering hydrocolloid as a barrier to reduces pressure at the interface.

**KEYWORD:** baby; cpap; hydrocolloid; skin breakdown

Article Info :

Article submitted on September 09, 2021

Article revised on November 18, 2021

Article received on Desember 07, 2021

DOI: [http://dx.doi.org/10.21927/jnki.2021.9\(4\).263-272](http://dx.doi.org/10.21927/jnki.2021.9(4).263-272)

---

## INTRODUCTION

The process of respiratory system adaptation is a very important time for all newborns. Approximately 97% of babies born have respiratory problems that require respiratory support (1) a noninvasive respiratory support modality used to manage newborns with respiratory distress, provides continuous pressure that helps prevent derecruitment of alveoli, increasing the lungs' functional residual

capacity, and thus decreasing the work of breathing. bCPAP can be used to manage various respiratory conditions in the newborn. In this prospective study, we describe our experience using bCPAP therapy as the primary respiratory support in a level III neonatal unit in Amman, Jordan. In addition to reporting therapeutic indications, durations, and side effects, we aimed to identify areas requiring improvement in bCPAP therapy in our population. Patients

and methods: This prospective observational study investigated the usage of bCPAP in the management of respiratory distress in newborns admitted to a Jordan University Hospital in Amman. The newborns were followed until discharge. The patients' demographic and clinical data were recorded. Results: A total of 143 babies (mean gestational age,  $36\pm 2.7$  weeks; mean birth weight,  $2,770\pm 1,800$  g. Since it was first introduced in 1971 by Gregory et al, the continuous positive airway pressure (CPAP) has become the standard of early support care in premature infants with respiratory distress syndrome in order to maintain functional residual capacity (FRC), and prevent atelectasis (2). The most common sign of respiratory distress was grunting (83%) followed by tachypnea (59%). Infants with respiratory distress require 6-48 hours of CPAP therapy (1) a noninvasive respiratory support modality used to manage newborns with respiratory distress, provides continuous pressure that helps prevent derecruitment of alveoli, increasing the lungs' functional residual capacity, and thus decreasing the work of breathing. bCPAP can be used to manage various respiratory conditions in the newborn. In this prospective study, we describe our experience using bCPAP therapy as the primary respiratory support in a level III neonatal unit in Amman, Jordan. In addition to reporting therapeutic indications, durations, and side effects, we aimed to identify areas requiring improvement in bCPAP therapy in our population. Patients and methods: This prospective observational study investigated the usage of bCPAP in the management of respiratory distress in newborns admitted to a Jordan University Hospital in Amman. The newborns were followed until discharge. The patients' demographic and clinical data were recorded. Results: A total of 143 babies (mean gestational age,  $36\pm 2.7$  weeks; mean birth weight,  $2,770\pm 1,800$  g. Although implementation

of CPAP is standard management, there is no consensus on when and how to wean stable infants from CPAP (3) as measured by functional residual capacity (FRC). The successful use of CPAP depends on several reasons such as patient selection, pathological changes, patient tolerance to CPAP and the sophistication of CPAP

The long-term use of CPAP has a potential risk of complications that can harm the baby such as aspiration, hemodynamic instability and nasal injury in the form of lesions on the bridge of the nose and columella (5). Nasal injury is a damage to the skin mucosa in the nose that can cause pain, infection, scarring, excoriation, and loss of nasal tissue that requires plastic surgery intervention (6). Injury to the nose will cause pain that will make the baby uncomfortable and increases the risk of intraventricular hemorrhage (7) to identify risks that come with using this interface, and to present actions for nasal injury prevention. Patients and Methods: Observational and descriptive study performed in neonatal intensive care unit (NICU). Application of a hydrocolloid nasal barrier can relieve nasal pressure, thereby reducing the risk of developing second-degree pressure ulcers in patients requiring CPAP (8). The material of hydrocolloid pads that are soft, flexible and safe to use hydrocolloid pads can prevent baby's nose injury due to CPAP (5).

In Indonesia, the incidence of nasal injury due to the use of CPAP has not been documented. The purpose of this study was to conduct a literature review regarding the benefits of using hydrocolloid pads for comfort and prevention of damage to the nasal skin in infants using CPAP.

## MATERIALS AND METHODS

The method uses a systematic review from several databases according to the interests and objectives, PRISMA in article selection as shown in Figure 1. The steps used in this method

are: 1) identifying clinical topics, 2) compiling clinical questions using PICO, 3) determining inclusion and exclusion criteria as literature search strategy, 4) conducting literature search based on predetermined keywords and criteria,

5) extracting and analyzing data, 6) elaborating the results.

The data was obtained from searching four electronic databases namely Sciene Direct, Pubmed, Proquest, and Google Scholar

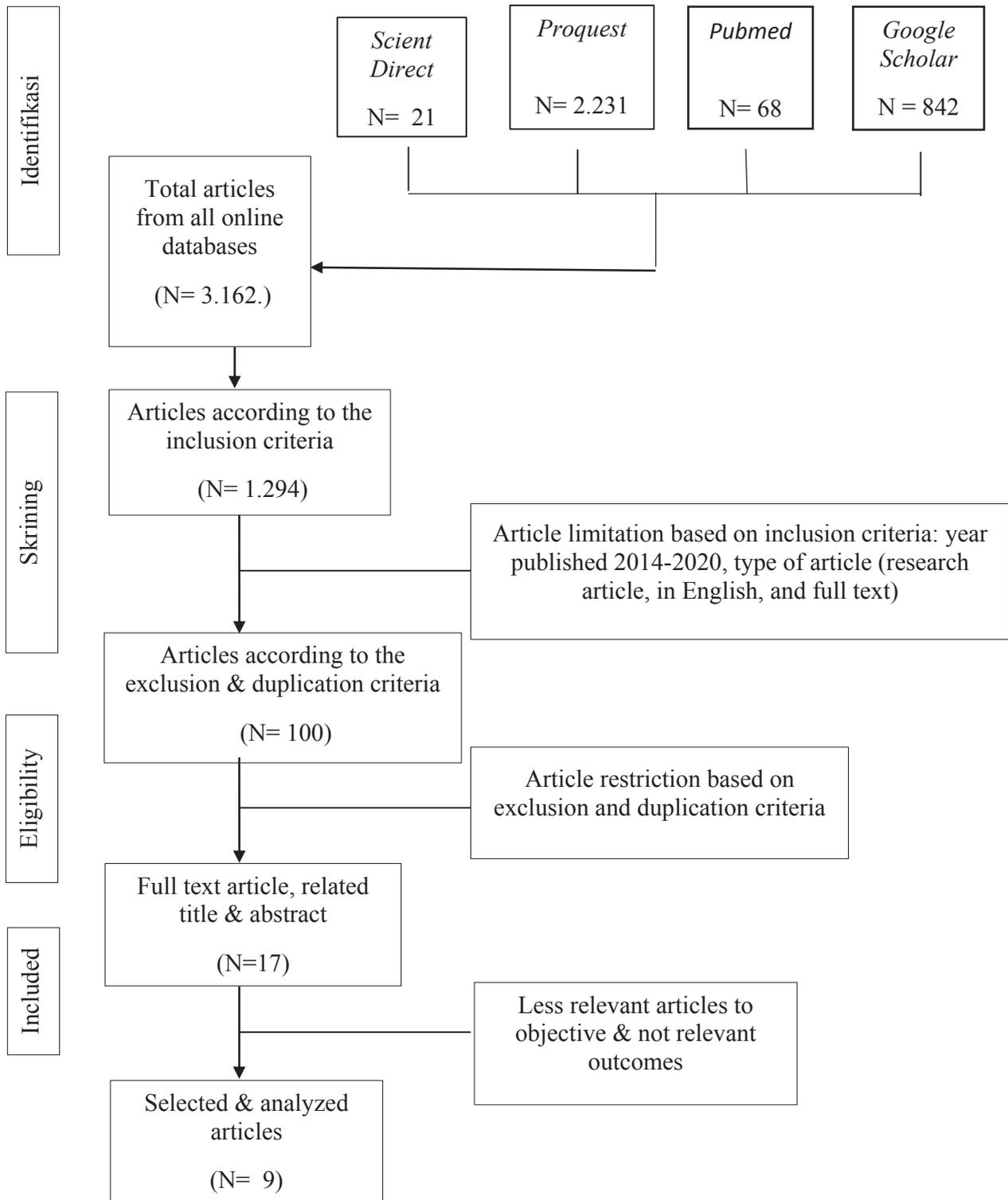


Figure 1. Article Selection Process based on the Prisma Model

**Table 1. Matriks of literature review**

Author and Year of Article Publication	Research Title	Objective	Method/ Design	Partisipant	Result
Tanveer Bashir, Srinivas Murki, Sai Kiran, Venkat Kallem Reddy, Tejo Pratap Oleti (2018)	Nasal mask in comparison with 'nasal prongs' or 'rotation of nasal mask with nasal prongs' reduce the incidence of nasal injury in preterm neonates supported on nasal continuous positive airway pressure (nCPAP): A randomized controlled trial	To evaluated the incidence and severity of nasal injury using two different nasal interfaces in three groups: rotation group, mask group and prong group.	RCT	N=226 Premature baby at 30 weeks' gestation and experiencing respiratory distress in the first 6 hours birth and require CPAP	Significant difference in the incidence of nasal injury between the masking group [n = 19/57 (33.3%)] and the prong group [n = 55/60 (91.6%)] and the rotation group [33/58 (56.9%) Nasal injury scores were significantly lower in the mask group compared to the rotation group and the Prong . group
Chien-Yi Chen, An-Kuo Chou, Yu-Lien Chen, Hung-Chieh Chou, Po-Nien Tsao, Wu-Shiun Hsieh (2016)	Quality Improvement of Nasal Continuous Positive Airway Pressure Therapy in Neonatal Intensive Care Unit	To accelerate the application of NCPAP therapy and reduce the incidence of nasal trauma	Experiment training	N: 59 medical staff N: 113 babies	Nursing protocols significantly reduced the incidence of nasal trauma in infant population (45.2% vs. 19.6%, pZ0.006), but not in infants with birth weight <1000 g.
Katherine M. Newnam, Jacqueline M. McGrath, Jeanne Salyer, Tracy Estes, Nancy Jallo, W. Thomas Bass (2015)	A comparative effectiveness study of continuous positive airway pressure-related skin breakdown when using different nasal interfaces in the extremely low birth weight neonate/	To identify differences in the frequency and severity of injuries nose between two interfaces  To describe the risk factors associated with nasal injury	RCT	377 baby in the level III NICU	fewer nose injuries were detected in the rotation group when compared to the mask and prong group. Predictors of nasal injury were number of days using nasal CPAP (p b 0.001) and mean current post-gestational age (p = 0.006)..
Dilini I. Imbulana, MBSc, Louise S. Owen, MD, Jennifer A. Dawson, PhD, Jane L. Bailey, RN, Peter G. Davis, MD, and Brett J. Manley, PhD (2018)	A Randomized Controlled Trial of a Barrier Dressing to Reduce Nasal Injury in Preterm Infants Receiving Binasal Noninvasive Respiratory Support	To find out the use of hydrocolloid nasal pads during binasal (CPAP), compared with no pads.	RCT	N= 167 baby	Infants in the barrier group had significantly lower rates of nasal injury compared to the non-barrier group: 18 of 53 (34%) vs. 31 of 55 (56%), respectively (P = .02), a significant difference detected on secondary respiratory outcome, or on morbidity.
Marty O Visscher PhD, Cynthia C White MSc RRT-NPS AE-C FAARC, Jennifer M Jones, Thomas Cahill MSc RRT-NPS FAARC, Donna C Jones PhD, and Brian S Pan MD (2018)	Face Masks for Noninvasive Ventilation: Fit, Excess Skin Hydration, and Pressure Ulcers	To investigated the factors contributing to pressure ulcers due to the use of face masks in NIV To identify skin disorders early and measure skin hydration to assess impact due to excess moisture using high-resolution color imaging.	Cohort study	N= 50 child	- 69% of participants had a diagnosis associated with craniofacial anomalies. - The difference in hydrated skin was without erythema (P < .05) and the smallest for cloth masks (P < .05). Different fit distance metrics for nasal,
Sunitha Kumari Byram, Y. Sivaramakrishna, M.S. Raju (2019).	Outcome of Bubble (CPAP) Continuous Positive Airway Pressure in Neonates with Respiratory Distress and its failure factors./	To Knowing the failure factors of using Bubble CPAP in premature and term neonates	Retrospective observational study	N=100 premature and mature baby	- CPAP failure rate is higher in preterm and LBW. - The overall failure rate is 36% (36 cases). - All infants who fail CPAP are placed on mechanical ventilation. - Overall survival rate of the study was 64% (64 cases).

Author and Year of Article Publication	Research Title	Objective	Method/ Design	Partisipant	Result
Mahnaz Jabraeil1, Majid Mahallei, Mohammad Arshadi, Asghar Mohammadpoorasl, Mahmood Shamshiri, Zakieh Salimi, Sakineh Karimipoor. (2017).	The Efficacy of a Protocolized Nursing Care on Nasal Skin Breakdown in Preterm Neonates Receiving Nasal Continuous Positive Airway Pressure	Investigated the effectiveness of an evidence-based clinical care protocol on nasal skin integrity in preterm newborns receiving NCPAP.	RCT	N=110 premature baby	NSCS scores were significantly lower in the intervention group who received nasal skin care according to the protocol than the control group who received routine nasal skin care (P = 0.000).
Michele Maruccia, Martina Ruggieri & Maria G Onesti (2015).	Facial skin breakdown in patients with non-invasive ventilation devices: report of two cases and indications for treatment and prevention	reported experience in the treatment and prevention of lesions, emphasizing the higher risk in certain age groups for developing them, such as premature infants and elderly patients with comorbidities.	Case Study	N= 1 premature baby and 1 elderly 71 years old	Daily disinfection of lesions followed by the application of a topical cream containing sodium hyaluronic acid (HA) salt was able to reduce the incidence of injury in the use of CPAP in the nose.
Li- hua Xie (2014).	Hydrocolloid dressing in preventing nasal trauma secondary to nasal continuous positive airway pressure in preterm infants	Comparing the incidence of nasal trauma secondary to nasal continuous airway pressure (nCPAP) protection with or without hydrocolloid dressing in preterm infants.	controlled prospective study	N=65	- Results showed Nine infants (2 in group A and 7 in group B) had nasal injury during nCPAP - Chi-square test showed that there was a statistically significant difference (P = 0.01) in the incidence of nasal injury between groups A and B.

between 2014 - 2020. The keywords used by the researcher are Baby; CPAP; hydrocolloid; skin breakdown. There are 3,177 articles were found, the researcher selected the articles according to the title and abstract and distinguished the articles from clinical questions. Articles that do not meet the inclusion criteria will be excluded. Each of the selected related articles was carefully read from the abstract, objective, and analytical data of the researcher's initial question to gather information about the effect of hydrocolloids on the degree of nasal skin damage in infants using CPAP. Inclusion criteria that have been set by the author include: articles that have titles and content that are relevant to the purpose, in English and full text, research articles published in 2014-2020. While the exclusion criteria determined by the author are articles that are reviewed systematically.

## RESULTS AND DISCUSSION

The articles that have been reviewed is 9 articles. The results of the article showed that participants in the study consisted of 50 children, 1 elderly, 59 medical staff and 1159 infants. There were six articles using infant participants, and one article using children and one article using infants and the elderly and one article using medical staff and infants. The analysis found three titles: Factors of nasal injury: gestational age, body weight; duration of cpap use and infant illness; type of interfaces: mask, prong and rotation; barriers such as moist gauze and hydrocolloids.

### Factors of Nasal Injury

#### **Gestational Age**

The incidence of nasal skin injury associated with nasal CPAP in neonates is 20 to 60%. It is more common in premature infants due to the characteristics of infants who have immature

skin and often require respiratory support for longer periods of time, both of which increase the risk for nasal trauma (9). The predictor of nasal injury was mean current post-gestational age ( $p = 0.006$ ) (10).

### **Weight**

The use of nursing protocols can significantly reduce the incidence of nasal trauma but does not apply to infants with birth weight <1000 g. Nasal trauma that often occurs is mild nasal hyperemia in smaller infants, especially in infants with birth weight <1000 g (9).

### **Duration of CPAP Usage**

The number of days of using CPAP is a factor in the occurrence of nasal injury in infants. More than 72 hours the risk of injury will be greater (10).

### **Baby Illness**

CPAP failure rate was higher in preterm and low birth weight. Premature and low birth weight will tend to experience respiratory emergencies such as apnea and RDS. Of the 36 cases studied the overall failure rate was 36% (11).

### **Type of Interface**

#### **Mask**

In a trial comparing prong vs mask vs mask rotation and prong as a nasal interface in the administration of nCPAP in preterm infants with respiratory distress, masking was superior to prong and mask rotation with nasal prongs in reducing nasal injury (12). The ease of use, softness and the mask design that adheres well to the nose are the reasons for nasal injury to be lower in the mask group.

#### **Prong**

Standard respiratory support used in newborns is CPAP. CPAP can increase oxygenation, maintain lung volume, and reduce

upper airway resistance, and reduce obstructive apnea. The prong is the most frequently used interface because it is less invasive (5). However, nasal trauma is common in infants using prong because local pressure from the prong to the nasal area and improper fixation causes excessive prong movement.

#### **Mask and Prong Rotation**

Less nasal injuries were detected in the rotation group when compared to the mask and prong group due to the use of CPAP (10).

### **Barrier**

#### **Moist Gauze**

The difference in skin injury that occurred on hydrated skin was without erythema and the smallest on cloth masks ( $P < .05$ ). The treatment of this study was daily disinfection of the lesions followed by application of a topical cream containing sodium hyaluronic acid (HA) salt, to prevent exacerbation of the injury (13).

#### **Hydrocolloid**

In contrast to Maruccia's study, imbulana (14), in his study revealed that infants in the hydrocolloid barrier group had significantly lower rates of nasal injury compared to the non-barrier group: NSCS scores were significantly lower in the intervention group receiving nasal skin care according to the hydrocolloid protocol than the control group receiving routine nasal skin care (15). Nine infants (2 in group A and 7 in group B) had nasal injury during nCPAP use in the control group (5).

### **DISCUSSION**

Based on the results of the article analysis, there are risk factors for injury to infants who using CPAP such as young gestational age (9; 10), low infant weight (9), duration of CPAP usage (10) and infant disease (11). Failure to adapt to the newborn causes the baby to experience an emergency in the respiratory system.. CPAP is

the most appropriate choice and has become a hospital standard for the care of infants with this case (14). CPAP Giving positive pressure to the airways aims to open the alveoli so that the gas exchange process can be carried out properly (2). In infants with young or premature gestational age, gas exchange in the lungs cannot occur due to a lack of surfactant in the alveoli (9; 10).

Another condition that also affects poor gas exchange in the lungs is low body weight. Surfactant production may be sufficient, however, surfactant cannot function properly and the small chest cavity in LBW infants does not allow lung capacity to be the same as in infants with normal weight (9).

The duration of CPAP use also contributes to nasal injury. Application of CPAP to premature infants takes an average of 3.2 days to cause injury. Examination of the nose and nostrils needs to be done carefully (5). Diseases of infants using CPAP are Respiratory Disorders Syndrome (56%) followed by Meconium Aspiration Syndrome (16%), Congenital Pneumonia (14%), Transient Tachypnea of Newborns (8%) and Birth Asphyxia (6%). The failure rate of CPAP use is related to the severity of the disease. Failure to use CPAP in this study was highest among infants with RDS disease (42%). No maturation of other organ structures such as skin in premature and low birth weight infants is a supporter of the risk of this nasal injury occurring (11).

In addition to the factors mentioned above, the use of this type of interface also contributes to the incidence of nose injuries. In another study on the comparison of prong vs mask vs mask rotation and prong as an interface, mask was superior to prong and mask rotation and prong in reducing nasal injuries from moderate to severe nasal injuries. Ease of use, softness and design of the mask are the reasons for the lower nasal injury in this group. The use of a mask significantly reduced CPAP failure [RR 0.63 (CI 0.45 to 0.88)] and the incidence of moderate to

severe nasal injury [RR 0.41 (CI 0.24 to 0.72)] (12). However, this opinion is not in line with research conducted by Xie (2014), which states that CPAP is the standard respiratory support used in newborns and the interface that is most often used is the prong because it is slightly invasive in the nostrils. Nasal trauma that can occur in infants using prongs is caused by local pressure from the prong to the nose area and improper fixation resulting in excessive branch movement (5). Injury to the nose will cause pain, making the baby cry and increasing the risk of intraventricular hemorrhage (7).

Nurses have an important role in the prevention of nasal injuries, careful monitoring and continuous evaluation is very helpful in preventing complications and maintaining infant comfort (16). One of the basic needs that must be met by nurses is comfort. Patient comfort can be provided by applying the nursing model application from Kolcaba (17). Kolcaba believes that a nurse can carry out nursing care that is comfortable for the patient.

In order to avoid injury and achieve comfort for the baby, preventive measures are taken, such as providing a barrier before sticking the baby's nose with CPAP (13), stating that skin injuries can occur if not properly hydrated. The skin will experience erythema, therefore daily disinfection of the lesion followed by application of a topical cream containing sodium hyaluronic acid (HA) salt is necessary. However, some studies do not agree with the proposed theory. According to the results of the study (11; 15; 5), it was stated that hydrocolloid was better in reducing the incidence of nasal injury in premature infants. Hydrocolloid dressing material is soft, flexible and inexpensive, as well as easy and safe to use, making the attachment between the interface to the nose tight and preventing the possibility of sliding and the skin will be protected from strong pressure by the flow of oxygen in the interface. Preliminary results show that the incidence and severity of

nasal injuries such as full-thickness necrosis of the skin around the nostrils and columella necrosis are significantly reduced.

## CONCLUSION AND RECOMMENDATION

Nasal injury due to CPAP can be influenced by gestational age, low body weight, duration of CPAP use and disease severity. The younger the gestational age and the lower the baby's weight, the higher the nose injury. Selection of the right interface, and the application of a barrier such as hydrocolloid will greatly help the baby get comfortable with CPAP and prevent nasal injury.

The use of hydrocolloids as a barrier in infants using CPAP is a grade c recommendation, with minimal or even non-existent side effects (Grade definitions, 2018). Providing holistic nursing care with attention to patient comfort will accelerate the patient's healing and will provide satisfaction for the patient. nurse. Comfort theory as part of professional nursing practice can be applied in the promotion of patient comfort.

## REFERENCES

1. Al-Lawama M, Alkhatib H, Wakileh Z, Elqaisi R, AlMassad G, Badran E, et al. Bubble CPAP therapy for neonatal respiratory distress in level III neonatal unit in Amman, Jordan: A prospective observational study. *Int J Gen Med.* 2019;12:25–30.\
2. Baldursdottir S, Falk M, Donaldsson S, Jonsson B, Drevhammar T. Basic principles of neonatal bubble CPAP: Effects on CPAP delivery and imposed work of breathing when altering the original design. *Arch Dis Child Fetal Neonatal Ed.* 2020;105(5):550–4.
3. Lam R, Schilling D, Scottoline B, Platteau A, Niederhausen M, Lund KC, et al. The Effect of Extended Continuous Positive Airway Pressure on Changes in Lung Volumes in Stable Premature Infants: A Randomized Controlled Trial. *J Pediatr* [Internet]. 2020;217:66-72.e1. Available from: <http://www.sciencedirect.com/science/article/pii/S0022347619309825>
4. Alqahtani JS, AlAhmari MD, Alqahtani S. Evidence based synthesis for prevention of noninvasive ventilation related facial pressure ulcers. *Saudi Med J* [Internet]. 2018;39(5):5. Available from: [www.smj.org.sa](http://www.smj.org.sa)
5. 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.Ribeiro, D. de F. C., Barros, F. S., Fernandes, B. L., Nakato, A. M., & Nohama, 'Percy. (2020). Nasal prongs: Risks, injuries incidence and preventive approaches associated with their use in newborns. *Journal of Multidisciplinary Healthcare*, 13, 527–537. <https://doi.org/10.2147/JMDH.S252017>
6. Milligan PS, Goldstein MR, Neonatologist A. Implementation of an evidence-based non-invasive respiratory support ( NIRS ) bundle in the NICU to decrease nasal injury complications. *J Neonatal Nurs* [Internet]. 2017;23(2):89–98. Available from: <http://dx.doi.org/10.1016/j.jnn.2016.05.003>
7. Ribeiro D de FC, Barros FS, Fernandes BL, Nakato AM, Nohama 'Percy. Nasal prongs: Risks, injuries incidence and preventive approaches associated with their use in newborns. *J Multidiscip Healthc.* 2020;13:527–37.
8. Bishopp, A., Oakes, A., Antoine-Pitterson, P., Chakraborty, B., Comer, D., & Mukherjee, R. (2019). The preventative effect of Hydrocolloid Dressings on nasal bridge pressure ulceration in Acute Non-Invasive Ventilation. *The Ulster medical journal*, 88(1), 17–20
9. Chen, C. Y., Chou, A. K., Chen, Y. L., Chou, H. C., Tsao, P. N., & Hsieh, W. S. (2017). Quality Improvement of Nasal Continuous Positive Airway Pressure Therapy in Neonatal Intensive Care Unit. *Pediatrics and Neonatology*, 58(3), 229–235. <https://doi.org/10.1016/j.pedneo.2016.04.005>

10. Newnam, K. M., McGrath, J. M., Salyer, J., Estes, T., Jallo, N., & Bass, W. T. (2015a). A comparative effectiveness study of continuous positive airway pressure-related skin breakdown when using different nasal interfaces in the extremely low birth weight neonate. *Applied Nursing Research*, 28(1), 36–41. <https://doi.org/https://doi.org/10.1016/j.apnr.2014.05.005>
11. Byram, S. K., Sivaramakrishna, Y., & Raju, M. S. (2019). Outcome of Bubble (CPAP) Continuous Positive Airway Pressure in Neonates with Respiratory Distress and its failure factors. *International Journal of Contemporary Medical Research [IJCMR]*, 6(7), 11–13. <https://doi.org/10.21276/ijcmr.2019.6.7.41>
12. Bashir, T., Murki, S., Kiran, S., Reddy, V. K., & Oleti, T. P. (2019). “Nasal mask” in comparison with “nasal prongs” or “rotation of nasal mask with nasal prongs” reduce the incidence of nasal injury in preterm neonates supported on nasal continuous positive airway pressure (nCPAP): A randomized controlled trial. *PLoS ONE*, 14(1), 1–11. <https://doi.org/10.1371/journal.pone.0211476>
13. Maruccia, M., Ruggieri, M., & Onesti, M. G. (2015). Facial skin breakdown in patients with non-invasive ventilation devices: Report of two cases and indications for treatment and prevention. *International Wound Journal*, 12(4), 451–455. <https://doi.org/10.1111/iwj.12135>
14. Imbulana, D. I., Owen, L. S., Dawson, J. A., Bailey, J. L., Davis, P. G., & Manley, B. J. (2018). A Randomized Controlled Trial of a Barrier Dressing to Reduce Nasal Injury in Preterm Infants Receiving Binasal Noninvasive Respiratory Support. *Journal of Pediatrics*, 201, 34-39.e3. <https://doi.org/10.1016/j.jpeds.2018.05.026>
15. Jabraeili, M., Mahallei, M., Arshadi, M., Mohammadpouras, A., Shamshiri, M., Salimi, Z., & Karimipoor, S. (2017). The efficacy of a protocolized nursing care on nasal skin breakdown in preterm neonates receiving nasal continuous positive airway pressure. *International Journal of Pediatrics*, 5(1), 4217–4225. <https://doi.org/10.22038/ijp.2016.7875>
16. Naha, N., Pournami, F., Prabhakar, J., & Jain, N. (2018). *Nasal Injury with Continuous Positive Airway Pressure: Need for BPrivileging^ Nursing Staff*. <https://doi.org/10.1007/s12098-019-02960-1>
17. Alligood, R. M. (2014). *Nursing theorist and their work*. United State of America: Mosby Elsevier.