CPAP protocol utilizing Nurse Angele's Wipes

Guidelines Flexi Trunk with NAW

Continuous Positive Airway Pressure –Golisano Children's Hospital, Fort Myers, Florida

Purpose: To provide guidelines for Nasal Continuous Positive Airway Pressure. With Flexi Trunk

Indications: (include but are not limited to)

1. Tachypnea

2. Respiratory distress as exhibited by nasal flaring, grunting and/or inspiratory retractions.

3. Respiratory distress syndrome, Transient tachypnea of the newborn, meconium aspiration syndrome pneumonia, congestive heart failure, pulmonary edema.

4. Apnea and bradycardia of prematurity

5. Post extubation respiratory support

6. Meconium aspiration syndrome

7. Tracheomalacia

8. Paralysis of the diaphragm

9. Improve Oxygenation

Contraindications:

1. Congenital abnormalities e.g., diaphragmatic hernia, choanal atresia, tracheoesophageal fistula, etc.

2. Nasal trauma/severe deformity that might be exacerbated by use of nasal prongs

3. Cardiovascular instability

4. Frequent apneas and bradycardia not responding to treatment with CPAP

Hazards/Complications

1. Pneumothorax

2. Abdominal distention

3. Nasal septum damage or necrosis

4. Nasal obstruction due to secretions or improper position of prongs

Equipment:

- Humidifier
- Heated Wire Circuit
- Sterile water for humidification
- Nasal Tubing Setup with bonnet or tortle and securement device
- Chin strap
- Appropriately Sized Nasal Mask and Prongs
- Angele's Wipes

Continuous Positive Airway Pressure –Golisano Children's Hospital, Fort Myers, Florida

Guidelines for Use of Nasal Continuous Positive Airway Pressure. With Flexi Trunk

- ❖ Infants < 30 weeks will be initiated on Flexi Trunk Nasal Tubing Setup with bonnet or tortle and securement device (Sweet, et al., 2023).
- ❖ Infants>30 weeks will be initiated on HHFNC (2 liters/ KG). Unless otherwise ordered by provider.
- ❖ Infants who are weaned to 1 liter will be placed on a standard nasal cannula with humidity.
- ❖ Bubble CPAP Checks will continue to be documented Q2.
- ❖ High Flow Checks in NICU only will be every 4 hours .
- Bubble CPAP therapy will be initiated with a mask interface.
- The Respiratory Therapist will alternate between mask and prong interfaces every 3 hours unless the patient is on minimal touch the interface changes will occur Q6 (Sivandan & Ballambattu, 2022).
- The Respiratory Therapist will coordinate touches and repositioning of all patients on Flexi trunk with bedside RN's.
- The patients skin integrity will be assessed. The device will be completely removed once per shift and a brief assessment will be completed every 3-6 hours with interface changes.
    - Tip of the Nose
    - Nares
    - Nasal Septum
    - Nostrils
    - Bridge of the Nose
    - Nose shape
    - Upper lip
    - Forehead
    - Scalp
- Respiratory Therapist will gently massage any area that the interface rests on including nasal areas, bridge of nose, forehead, and upper lip using Nurse Angele's Wipes every 3-6 hours with interface changes (Fu, Li, Li, & Shi, 2024).
- Respiratory therapist will document any skin changes in the Electronic Medical Record, under the Lines, Drains, and Airways (LDA) Flow sheet, a respiratory clinical note, as well as notify the nurse, and the provider.
- Babies with severe breakdown will be placed on non-invasive with Opti flow.
- Bonnets will be changed once weekly.
- Circuits will be changed Q14 days.

Delivery Room

- Patients requiring Bubble CPAP at delivery will be initiated on the flexi trunk device with nasal mask.
- Infants requiring prongs will be initiated on High Flow.

MRI

- Neonatal dry vent circuit for flexi trunk patients.
- Nasal cannula for Opti flow patients.

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CPAP protocol utilizing Nurse Angele's Wipes

Evidence on Using Oils for Skin Protection and Prevention

Original Article

Summary of the best evidence for the prevention of nasal injury in preterm infants with nasal noninvasive ventilation

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Background: Due to immaturity, the nose of preterm infants can easily be injured, by even a short application of a nasal device. However, 20% to 60% of preterm infants suffer nasal damage while using nasal continuous positive airway pressure (NCPAP) due to weak skin tissue, prolonged use of nasal device, and improper nursing practices, leading to increased risk of infection and decreased compliance and tolerance. In this study, we retrieved, obtained and integrated the related evidences of prevention of nasal injury in premature infants with nasal noninvasive ventilation to provide reference for clinical practice.

Methods: We searched the relevant guidelines, expert consensus, evidence summaries and systematic reviews in the databases and guideline websites of the National Institute for Health and Care Excellence (NICE), Scottish Intercollegiate Guidelines Network (SIGN), the Agency for Health care Research and Quality (AHRQ), Guidelines International Network (GIN), the World Health Organization (WHO) guideline websites, Registered Nurses' Association of Ontario (RANO), Association of Women's Health, Obstetric and Neonatal Nurses (AWHONN), European Pressure Ulcer Advisory Panel (EPUAP), Yi Maitong, British Medical Journal best-practice, Cochrane Library, UpToDate, Embase, PubMed, China National Knowledge Infrastructure (CNKI), Wanfang. The search was limited to the time of library establishment to February 2023.

Results: In total, 16 articles were included, including six guidelines, three expert consensuses, two evidence summaries and five systematic reviews. Twenty-eight pieces of evidence were summarized from six aspects: risk assessment, ventilation and connection, skin protection, skin assessment, training and support, and continuous quality improvement.

Conclusions: This study summarized the best evidence for the prevention of nasal injury in premature infants through nasal noninvasive ventilation. It is suggested that nurses should consider the actual clinical situation when applying the suggestions from the evidence, formulate corresponding nursing measures, and reduce the occurrence of nasal injury in premature infants.

Keywords: Premature infant; noninvasive ventilation; nasal; pressure injury; evidence-based nursing

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Introduction

Nasal noninvasive ventilation including nasal continuous positive airway pressure (NCPAP), noninvasive intermittent positive pressure ventilation (NIPPV), nasal high flow ventilation (NHFV) and high flow nasal cannula (HFNC) (1), can treat primary respiratory diseases in preterm infants, stabilize respiratory status, and also assist in extubating intubation. Among them, NCPAP is the "gold standard" form of noninvasive ventilation in preterm infants (2). However, due to fragile skin tissue, long nasal interface pressure time, improper nursing operations, etc., 20–60% of preterm infants using NCPAP suffer from damage to the oral, nasal and peripheral skin mucosa, leading to increase in infection risk, and decline in treatment compliance and tolerance. Some severe cases exhibit irreversible nasal injuries such as nasal vestibular stenosis, nasal deformity, nasal granuloma, and even require surgical correction (3,4). As more and more premature infants are using noninvasive ventilation for treatment, it is very important to standardize the prevention methods of nasal injury for premature infants from nasal noninvasive ventilation. At present, guidelines or expert consensus on neonatal skin management have provided guidance on this (5,6), but the related evidence is scattered and there are conflicting opinions, lacking good guidelines for clinical nursing work. Therefore, this study systematically summarizes high-quality evidence, providing a reference for standard clinical nursing practice. This study has been registered at the Fudan University Centre for Evidence-Based Nursing (No. ES20220917).

Highlight box

Key findings

- The evidence of nose protection in noninvasive ventilated preterm infants was summarized.

What is known and what is new?

- At present, there are some studies of nose protection in noninvasive ventilated preterm infants, which scattered in guidelines, systematic reviews, evidence summaries and expert consensus, *et al*.
- We summarized the existing 28 pieces of relevant evidence from six aspects, including risk assessment, ventilation and connection, skin protection, skin assessment, training and support, and continuous quality improvement.

What is the implication, and what should change now?

- We provide an evidence-based basis for clinical managers to improve the prevention of nasal noninvasive ventilation related nasal injury in premature infants. It is suggested that nurses should fully consider the medical environment and the family economic status and willingness when applying evidence, and formulate a localized and individualized management plan, so as to reduce the incidence of nasal damage in noninvasive ventilated preterm infants and improve the quality of nursing.

Methods

Retrieval strategy

Literature retrieval was performed in the databases of National Institute for Health and Care Excellence (NICE), Scottish Intercollegiate Guidelines Network (SIGN), the Agency for Health care Research and Quality (AHRQ), Guidelines International Network (GIN), the World Health Organization (WHO) guideline websites, Registered Nurses' Association of Ontario (RANO), Association of Women's Health, Obstetric and Neonatal Nurses (AWHONN), European Pressure Ulcer Advisory Panel (EPUAP), Yi Maitong, British Medical Journal bestpractice, Cochrane Library, UpToDate, Embase, PubMed, China National Knowledge Infrastructure (CNKI), Wanfang. We used the keywords "infant,newborn/Infant, premature/Infant,Small for Gestational Age/newborn/ neonate/premature/preterm

infant" and "non-invasive respiratory support/NIV/NIPPV/CPAP/HFNC" and "skin trauma/skin damage/skin breakdown/skin compromise/ pressure injury/pressure ulcer/pressure sore/nasal trauma/ nasal injury". The retrieval time was from the database establishment to February 2023.

Literature inclusion and exclusion criteria

The inclusion criteria were as follows: (I) participants were hospitalized preterm infants; (II) research on the pressure injury risk assessment of non-invasive ventilation, use of connecting devices, dressing application, skin assessment, etc.; (III) literature types were guideline, expert consensus, evidence summary, best clinical practice manual, clinical decision, systematic review; (IV) language in either Chinese or English. The exclusion criteria were as follows: (I) repetitive literature; (II) inaccessible full-text document; (III) for systematic reviews cited by guidelines, systematic reviews were excluded if all available evidence related to this study was in the guidelines; (IV) the most recent guidelines were included if they were updated by the same organization or individual; (V) research plan or proposal.

Literature screening

Two researchers independently screened the searched studies by reading the titles and abstracts and excluded unqualified articles. If there was a difference of opinion between the two researchers, a third one was consulted to resolve the disagreement. All three researchers were nursing postgraduates who had completed courses in evidencebased nursing.

Literature quality evaluation criteria and process

The guidelines were evaluated by Appraisal of Guidelines for Research and Evaluation II (AGREE II) (7), which includes 6 domains and 23 items. In addition, there were two overall assessment items. Each item was rated on a scale from "strongly disagree" to "strongly agree" with scores ranging from 1–7, where higher scores indicate a higher level of item compliance. The domain score was the sum of all evaluators' ratings for each item within that domain. It was then standardized by the formula: (actual score for each domain − minimum possible score)/ (maximum possible score for each domain − minimum possible score) × 100%. If the score for each domain is ≥60%, it was classified as a grade A recommendation. If ≥3 domains have scores ≥30% and at least one domain has a score <60%, it was classified as a grade B recommendation. If ≥3 domains have scores <30%, it was classified as a grade C not recommended. The expert consensus and systematic review adopted the corresponding evaluation criteria from the Australian Joanna Briggs Institute (JBI) Centre for Evidence-Based Healthcare (2016 edition) (8,9), while the evidence summaries were evaluated by Critical Appraisal for Summaries of Evidence (CASE) (10).

The quality assessment of the literature was independently conducted by two researchers. In case of conflicting opinions or uncertainty, a third researcher was consulted to make the final decision on whether to include or exclude the literature. All three researchers were nursing postgraduates who had completed courses in evidencebased nursing.

Criteria for determining evidence level and recommendation level

Researchers extracted and integrated the evidence from included literature, and when conflicts arose from different sources of evidence, they followed the principles of prioritizing evidence-based evidence, high-quality evidence, and the most recently published authoritative literature. Two researchers used the JBI grading of evidence and recommendation system (2014 edition) (11), and independently classified the included evidence into levels 1–5 based on the type of research design of the source documents of the evidence. They determined the strength of evidence recommendation as grade A or grade B according to the JBI recommendation level of the evidence, combined with the FAME principle of evidence (feasibility, appropriateness, meaningfulness and effectiveness) proposed by JBI.

(I) Classification of evidence levels:

- (i) Level 1: randomised controlled trial (RCT) or other type of experimental study.
  - 1a: systematic review of multiple RCTS; 1b: systematic review of one or more RCTS and other intervention studies; 1c: single RCT.
- (ii) Level 2: experimental study.
  - 2a: systematic review of multiple quasiexperimental studies; 2b: systematic review of multiple quasi-

experimental and other low-quality interventional studies; 2c: single prospective quasiexperimental study with a control group.

(iii) Level 3: observational and analytical study.

- **3a: systematic review of multiple cohort studies; 3b: systematic review of multiple cohort studies versus other low-quality observational studies; 3c: single cohort study with a control group.**

(iv) Level 4: observational-descriptive study.

- **4a: systematic review of multiple descriptive studies; 4b: single-item cross-sectional study; 4c: pathological series study.**

(v) Level 5: expert opinion, basic research.

- **5a: systematic review of a pair of expert opinions; 5b: expert consensus; 5c: basic research, single expert opinion.**

(II) **Recommendation ratings:**

(i) A: strongly recommended because supported by adequate evidence.

(ii) B: weakly recommended because supported by some evidence.

Table 1 Characteristics of included studies (n=16)

Included articles	Source	Type of the article	Topic of the article	Year
Dilini I. Imbulana *et al.* (2)	PubMed	Systematic review	Nasal injury in preterm infants receiving non-invasive respiratory support: a systematic review	2017
Tongling Yang *et al.* (5)	CNKI	Expert consensus	Expert consensus on the assessment points and predictive nursing of neonatal iatrogenic skin injury	2020
Evidence-Based Medicine Group, Neonatologist Society, Chinese Medical Doctor Association (6)	CNKI	Clinical guideline	Guidelines for neonatal skin management in the neonatal intensive care unit (2021)	2021
JSPU (12)	JSPU	Clinical guideline	JSPU Guidelines for the Prevention and Management of Pressure Ulcers (3rd Ed.)	2014
NICE (13)	NICE	Clinical guideline	The prevention and management of pressure ulcers in primary and secondary care	2014
WOCN (14)	WOCN	Clinical guideline	WOCN Guideline for Prevention and Management of Pressure Injuries (Ulcers)	2016
AWHOMM (15)	AWHOMM	Clinical guideline	Neonatal skin care (fourth edition-based clinical practice guideline)	2018
NPIAP/EPUAP/PPPIA (16)	NPIAP/EPUAP/PPPIA	Clinical guideline	Prevention and Treatment of Pressure Ulcers: Clinical Practice Guideline	2019
WUWHS (17)	UpToDate	Expert consensus	Role of dressings in pressure ulcer prevention	2019
Dan Berlowitz *et al.* (18)	UpToDate	Expert consensus	Prevention of pressure-induced skin and soft tissue injury	2022
Xiaoli Liu *et al.* (19)	CNKI	Evidence summary	Evidence summary of prevention of Noninvasive Ventilation related facial Pressure Injuries	2019
Qi Zhao *et al.* (20)	CNKI	Evidence summary	Summary of best evidence regarding prevention and management of medical device related pressure injuries	2019
Jun Zhang *et al.* (21)	CNKI	Systematic review	Effects of dresings in the prevention of facial and nasal bridge pressure ulcers caused by the application of noninvasive positive pressure ventilation: a network meta analysis	2016
Jodi Herron Behr *et al.* (22)	PubMed	Systematic review	Prevention Strategies for Neonatal Skin Injury in the NICU	2020
Shaam Bruet *et al.* (23)	PubMed	Systematic review	High-flow nasal cannula versus nasal continuous positive airway pressure for respiratory support in preterm infants: a meta-analysis of randomized controlled trials	2022
Raj Prakash *et al.* (24)	PubMed	Systematic review	Masks versus prongs as interfaces for nasal continuous positive airway pressure in preterm infants	2022

Results

Results of literature screening

A total of 1,867 literatures were retrieved in this study. After de-duplication, preliminary screening of titles and abstracts, 30 articles were obtained. Four articles aiming at adults, nine incompatible research types, and two updated guidelines were excluded, leaving a total of 16 articles, including six guidelines (6,12-16), three expert consensuses (5,17,18), two evidence summaries (19,20), and five systematic reviews (2,21-24). The basic characteristics of the included literatures are shown in *Table 1*.

Quality evaluation results of the included literature

Quality evaluation results of the guidelines

This study included six guidelines (6,12-16). Two researchers independently scored all guidelines and calculated the standardized scores for each field, all were recommended at A level, as shown in *Table 2*.

Table 2 Results of guideline quality evaluation (n=6)

Included articles	Scopes and objects	Participant	Rigor of guidelines	Clarity of guidelines	Application of guidelines	Independence of guidelines	≥30% field number (n)	≥60% field number (n)	Recommendation level
Evidence-Based Medicine Group, Neonatologist Society, Chinese Medical Doctor Association (6)	80.6%	80.6%	71.9%	72.2%	70.8%	75.0%	6	6	A
JSPU (12)	80.6%	77.8%	66.7%	77.8%	66.7%	70.8%	6	6	A
NICE (13)	80.6%	75.0%	79.2%	72.2%	77.1%	91.7%	6	6	A
WOCN (14)	75.0%	88.9%	76.0%	75.0%	68.8%	91.7%	6	6	A
AWHOMM (15)	91.7%	88.9%	88.5%	94.4%	77.1%	95.8%	6	6	A
NPIAP/EPUAP/PPPIA (16)	83.3%	72.2%	76.0%	80.6%	75.0%	87.5%	6	6	A

Recommendation level: A, the score for each domain is ≥60%; B, ≥3 domains have scores ≥30% and at least one <60%; C, ≥3 domains have scores <30%.

Quality evaluation results of the expert consensuses

This study included three expert consensuses (5,17,18). The evaluation results of all items were "yes", these articles were clear in opinion, and the quality were relatively high, so adopted.

Quality evaluation results of the evidence summaries This study included two evidence summaries (19,20). Except for the evaluation result of "Is the evidence grading system transparent and translatable?" by Liu *et al.* (19) was "partially", the rest were all "yes". Except for the evaluation result "Is this summary applicable to your patients?" by Zhao *et al.* (20) was "partially", the rest were all "yes". The overall quality was good, so they were adopted.

Quality evaluation results of the systematic reviews This study included four systematic reviews (2,21-23). The study by Behr *et al.* (22), except for the evaluation items "Is the literature quality evaluation independently completed by two or more evaluators?" and "Are certain measures adopted to reduce errors when extracting data?" were "unclear", other items were all "yes". The research of Bruet *et al.* (23), Imbulana *et al.* (2), Zhang *et al.* (21), all items were "yes". These papers were included after an overall evaluation.

Summary of evidence

For the final 16 included articles, 104 pieces of relevant evidence were obtained. After the rigorous selection and organization by the research team, they were finally summarized into six aspects: risk assessment, ventilation and connection, skin protection, skin evaluation, training and support, continuous quality improvement, with a total of 28 pieces of best evidence, as shown in *Table 3*.

Discussion

Risk assessment

There are 50% of newborn medical device-related pressure injuries (MDRPI) occur on the nose, which is also the most common site (4). At present, there is a lack of targeted nasal injury risk assessment tools. Guidelines (15) and expert consensus (5) related to neonatal skin care recommend the use of the neonate/infant Braden-Q scale or Neonatal Skin Risk Assessment Scale (NSRAS), assessing neonatal skin pressure injury risk from factors such as gestational age, activity level, responsiveness, nutrition, and soaking. Compared with full-term infants, preterm infants have poor skin barrier function, less subcutaneous fat in the nose, and longer respiratory support time, making them a high-risk group for nasal injury. Research shows that for every 500 g decrease in birth weight of a preterm infant, the relative risk of nasal injury increases by 6.32 times (4), and nasal masks can significantly reduce the incidence of nasal injury compared to nasal prongs (25). Therefore, in addition to using structured tools to assess the risk of nasal injury in premature infants, it is also necessary to individually assess

high-risk factors for internal and external nasal injuries, such as premature infant weight, physiological abnormalities, and the use of nasal prongs or masks (15). In

Table 3
Best evidence for the prevention of nasal injury in preterm infants with nasal noninvasive ventilation

Category	Evidence content	Evidence level	Recommendation level
Risk assessment	1. It is recommended to use structured tools to assess the risk of skin damage when the patient is admitted and when the patient's condition changes, and to interpret the evaluation results with clinical judgment and record them. Commonly used are the neonate/infant Braden-Q scale and NSRAS. Currently, there is a lack of tools for assessing the risk of nasal skin damage in newborns (5,16)	5b	A
	2. Medical staff should identify risk factors for nasal injury, including physiological abnormalities in premature infants (such as edema, dehydration, hypotension, hypoglycemia, epidermolysis bullosa), and the use of nasal prongs and masks (such as type, material, model, and wearing method, continuous use time) (2,5,15)	1b	A
	3. It is recommended to utilize standard tools for measuring head circumference and nose size. In addition, it is important to select nasal prongs or masks that are compatible and soft, and replace these devices promptly as the patient gains weight (2,16)	1b	B
Ventilation and connection	4. It is suggested that use a noninvasive respiratory support cap to avoid extra vertical pressure, friction, or shear force. The cap should be appropriately tight (5,6,16)	5b	A
	5. Medical staff should ensure adequate space between the nasal prong and nasal mucosa to prevent complete insertion of the prong into the nasal cavity (5)	5b	A
	6. A plan for the interruption and alternative use of noninvasive ventilation connections is warranted (2,6,16)	1c	A
	7. Use of masks compared with prongs as the nasal CPAP interface may reduce treatment failure and nasal injury. When conditions permit, it is advisable to alternate between the use of nasal prongs and masks every 2–4 hours, particularly for preterm infants weighing less than 1,500 g (5,24)	1b	A
	8. It is recommended to massage the nasal cavity with a moisturizing oil during the process of alternation (2)	1b	A

Table 3 ***(continued)*** ***(continued)***

Category	Evidence content	Evidence level	Recommendation level
Skin protection	9. The temperature in the premature infant room is controlled at 24–26 ℃, and the humidity is 55–65%. It is necessary to use an incubator with temperature and humidity control functions (5,15)	2c	A
	10. Medical staff should conduct a nutritional assessment on admission and when the condition of premature infants changes, and develop a nutritional support plan to actively correct nutritional problems (14,15,18)	4c	B
	11. Medical staff should keep the skin under the noninvasive ventilation device clean and moderately moist. It's recommended to use a gentle cleanser with neutral or mildly acidic (pH 5.5–7.0) instead of hot water for skin cleaning (15,18,19)	5b	A

Table 3

	12. It is recommended to use dressings preventively to protect areas under pressure such as the nose, philtrum, and both cheeks of preterm infants. This method can also better seal the nostrils during non-invasive respiratory support (2,20)	1b	A
	13. Medical staff should consider the dressing's ability to control moisture and microenvironment, the ease of application and removal, and the dressing doesn't contain allergenic components. Commonly used are silicone, hydrocolloid, and foam dressings (17,20)	5b	B
	14. The dressing needs to be cut into shapes that match the anatomical position, with a size that can cover the risk area and overlap with surrounding skin (17,20)	5b	A
	15. When using a dressing, medical staff are advised to: (I) follow the manufacturer's instructions; (II) clean and dry the skin of nose before applying the dressing, and apply the dressing smoothly along the texture of skin without tension, ensuring no gaps between the dressing and device; (III) monitor and evaluate the dressing at least once a day (5,17,19)	5b	B
	16. When medical staff are changing the dressing, it's recommended to (I) regularly replace the dressing according to the effective period of use, or replaced promptly in cases where the dressing cannot stick completely, or if there are damages, displacements, creases, looseness, or saturation; (II) the adhesive part is thoroughly permeated before each replacement, and after removing the dressing at 180°, the skin should be observed and cleaned; (III) the selection of dressing, skin conditions, changing time, and reasons should be recorded in detail (5,17)	5b	A
	17. Dressings should be stopped when it is not suitable or the risk of pressure injury is reduced, and it's crucial to document the time and reason for the termination. Additionally, medical staff should explain whether or how to continue using the dressing when transferring or discharging (17)	5b	B
Skin evaluation	18. It is recommended to evaluate the contact areas of the device and the surrounding skin, especially the nostrils and nasal septum. Attention should be given to the assessment of mucosal integrity, moisture, color, swelling, hardening, blisters, exudation, and erythema unaltered by pressure (15,18)	1c	A
	19. A well-trained caregiver assesses the mucous membrane of the skin around the medical device contact site more than 2 times per day (6,16)	5b	A
	20. During evaluation, medical devices should be moved as far as possible without affecting treatment. If using an opaque dressing, it may need to be peeled open, and evaluation results should be recorded in detail (17,19)	5b	A

Table 3 ***(continued)*** ***(continued)***

Category	Evidence content	Evidence level	Recommendation level
Training and support	21. Healthcare personnel should be regularly evaluated concerning their knowledge and attitudes towards the prevention of nasal injuries associated with noninvasive respiratory support in premature infants, and develop and implement multi-level educational plans (16)	3c	A
	22. Medical staff should be regularly trained, including precautions for the use of noninvasive respiratory support devices, risk assessment, skin evaluation, skin protection, and other related content (16,19)	5b	A

Table 3

	23. It is suggested that experienced medical staff train parents, including the impact of nasal injuries, early signs of nasal injuries, techniques and equipment for preventing nasal injuries, etc. When the parents' abilities and the condition permit, they can participate in the decision-making and care of their infants (13,19)	5b	B
	24. It is recommended to provide timely and individualized information to parents through regular telephone consultations and remote assessments by medical staff (12)	5b	B
Continuous quality improvement	25. It is recommended to provide adequate human resources, forming a multi-disciplinary intervention team consisting of doctors, nurses, dieticians, and respiratory therapists (12,15,18,19)	5b	B
	26. At the organizational level, it is suggested to prevent nasal injury from noninvasive respiratory support in premature infants as a quality improvement project (16)	2c	A
	27. It is suggested to formulate and implement evidence-based structured and targeted quality improvement plans (16)	1b	A
	28. Medical staff should regularly monitor, analyze and evaluate the quality of pressure injuries prevention, and continuously improve measures (16)	2c	A

Evidence level: 1b, systematic review of one or more RCTs and other intervention studies; 1c, single RCT; 2c, single prospective quasiexperimental study with a control group; 3c, single cohort study with a control group; 4c, pathological series study; 5b, expert consensus. Recommendation level: A, strong recommendation; B, weak recommendation. NSRAS, Neonatal Skin Risk Assessment Scale; CPAP, continuous positive airway pressure; RCT, randomised controlled trial.

studies related to pressure injury risk warning, Jiang *et al.* (26) monitored local blood supply and hypoxia through skin temperature, thereby predicting the occurrence of pressure injuries. Therefore, exploring a pressure injury risk warning model for premature infants based on skin temperature monitoring might have more guiding significance for the prevention of nasal injuries (4).

Connecting interface

Nasal interface usually consists of a head fixation cap, forehead nasal tube or generator, and nasal prong or mask, etc. (4). It is reported that choosing a softer silicone or latex type nasal prong or mask can relatively reduce skin redness and breakdown. Setting an air flow sensor system while using a head fixation hat can also help reduce the incidence of nasal pressure sores (4). In addition, all five (2,6,16,19,22) **of the articles included in this study suggest alternating use of nasal prongs and masks, which can help to relieve the pressure on sensitive areas, such as nasal septum and nostrils. Yang *et al.* (5) in the expert consensus now suggest alternating the nasal prong or mask every 2–4 hours. Zhu *et al.* (27) found that alternating prongs and nasal mask of NCPAP Q4h is conducive to reduce nasal pressure damage and improving the comfort of premature infants, but earlier research suggested alternating every 8 hours (28). So, the optimal interval time to achieve the lowest rate of nasal injury still needs to be further determined, and the available trial data provide evidence that use of masks compared with prongs as the NCPAP interface may reduce treatment failure and nasal injury (24). Meanwhile, using moisturizing oil to massage the noses during switching period can**

moisturize the skin, protect the stratum corneum, and enhance the epidermal barrier function. However, some moisturizers can negatively affect the skin barrier function of preterm infants, such as mustard oil and olive oil, which can increase transepidermal water loss (TEWL) and reduce skin barrier function (15).

Skin protection

The weight of connecting interface and the pressure applied to locality for a long time can cause tissue ischemia and hypoxia or even necrosis. Nasal prongs often lead to injury to the inner wall of nostril and the skin of nasal septum, while nasal masks often cause damage to the philtrum and nasal root (4). In addition, factors such as the body's nutritional status and skin environment also affect the occurrence of localized pressure injuries. Therefore, we concluded skin protection points from environmental temperature and humidity control, nutritional support, routine skin care, and preventive use of dressings. It is reported that seven types of dressings can prevent pressure injuries to the nose and face of patients receiving noninvasive positive pressure ventilation (21), and the preventive use of nasal barrier dressings within 48 hours can reduce nasal injuries in preterm infants receiving nasal noninvasive ventilation, with no adverse reactions and at reasonable costs (29). We provide a detailed summary of the key points of dressing selection, cutting, usage, and replacement. Notably, the dressing needs to be cut into a shape that fits the position and size of the preterm infant's nose, such as pig nose-shaped, saddle-shaped, vertical nose stickers, and other shaped dressings, which have a protective effect on the nose of preterm infants receiving noninvasive ventilation (4,30). Zhang *et al.* (31) cut hydrocolloid dressings into a "工" shape to fix the nasal prong, with a usage area of only 3.3 cm^2, reducing waste while being simple to produce, sturdy, and durable.

Skin evaluation

Skin assessment is key to preventing and detecting pressure injuries early. The guidelines recommend assessing the skin in contact with medical devices and around it more than twice a day, paying particular attention to the integrity of nostril and nasal septum mucosa, humidity, color (6,15,16). The degree of nasal skin injury is commonly assessed by redness (mild), bruising (moderate), and skin breakdown (severe) (2). A nasal injury assessment scale (32) is often used, scoring from six dimensions: nose tip, nasal septum, nostrils, nasal shape, bridge of the nose, and upper lip. Some researchers predict the occurrence of pressure injuries by assessing local blood supply and hypoxia conditions through skin temperature monitoring (31). In the future application of evidence, it is necessary to develop specific tools suitable for assessing neonatal nasal injuries, and to standardize the language used to describe and record nasal injuries.

Training and support

The level of knowledge of medical personnel about the prevention of nasal injury in preterm infants under noninvasive ventilation is closely related to the state of nasal injury. Based on the knowledge assessment of neonatal intensive care unit (NICU) medical personnel, Anjum *et al.* (33) used lectures and group discussions to train in nasal prong and mask selection, tube fixation, etc., improving the knowledge level of medical staff and achieving a decrease in nasal traumas from 79% to 26% within 16 weeks. In addition to training healthcare personnel, the guideline (13) recommends that experienced healthcare personnel provide timely and personalized information to family members of patients at high risk for pressure injuries. With the growing consensus on high-quality care for hospitalized children with family involvement, as well as the development of Family Integrated Care model in NICUs, more and more parents of premature infants can enter the NICU after receiving systematic training (34). The training provides baseline knowledge and nasal injury related knowledge on non-invasive ventilation, which helps parents get involved in the early care and decision-making for premature infants. At the same time, it is beneficial for some premature infants to be smoothly transitioned to home oxygen therapy after discharge.

Continuous quality improvement

Standardized quality management is of great importance for the prevention of pressure injuries in preterm infants under non-invasive ventilation. The guidelines recommend forming a multidisciplinary team comprised of doctors, nurses, dieticians, and respiratory therapists, under the premise of sufficient staffing. This team should take the prevention of non-invasive ventilatory nasal injuries in premature infants as a quality improvement project, and jointly formulate a quality improvement plan (16,19). Based

on a multidisciplinary team, Chen *et al.* (35) have designed a movable trolley in the NICU equipped with various NCPAP sets. According to the standard care plan, it specifies the selection and fixation methods for NCPAP connecting interface, ultimately reducing the incidence of nasal trauma by 25%. In addition, there is certain clinical reference value in continuously tracking the results of quality improvement, analyzing controllable risk factors, dynamically adjusting improvement plans and care schemes, for improving the effects of quality improvement and reducing the incidence of nasal injury.

Conclusions

For the prevention of nasal injury in preterm infants under nasal non-invasive ventilation, this study integrates 28 optimal evidence from six aspects: risk assessment, ventilation and connection, skin protection, skin assessment, training and support, continuous quality improvement, and provides an evidence basis for clinical managers to improve the nursing workflow and select appropriate strategies. It is recommended that nursing staff should fully consider medical environment, department environment, population differences, economic basis and willingness when applying evidence, comprehensively assess each piece of evidence and select applications, formulate localized and individualized management plans, thereby reducing the incidence of nasal injury in preterm infants under nasal noninvasive ventilation and improving the quality of care.

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Footnote

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