Systematic review

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Prevention of non-invasive ventilation injuries in preterm infants: a systematic review

Prevenção de lesão por uso de dispositivo de ventilação não invasiva em prematuros: revisão sistemática

Prevención de lesiones con ventilación no invasiva en bebés prematuros: revisión sistemática

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ABSTRACT

Objective: To identify scientific evidence regarding preventive care for pressure injuries related to the use of noninvasive ventilation in preterm newborns.

Method: Systematic literature review, conducted in the databases PubMeb/Medline, EMBASE, Scopus, Web of Science, CINAHL-EBSCO, and LILACS, via the Virtual Health Library. Randomized controlled clinical trials were included, with no language restrictions and no time frame. Methodological quality was assessed using the Grading of Recommendations Assessment, Development and Evaluation system, and risk of bias was assessed using the Revised Cochrane risk-of-bias tool for randomized trials.

Results: The search identified nine randomized clinical trials, published in English, between 2010 and 2021. Most studies were rated as having high quality of evidence. All performed random allocation and had low risk of bias.

Conclusion: High-quality evidence recommends the adoption of systemic rotation between mask and nasal prongs, associated with the use of a hydrocolloid protective barrier, as a priority preventive intervention to reduce pressure injuries in preterm infants undergoing noninvasive ventilation. Integrated with daily inspection of skin integrity and adequate maintenance of humidification, this strategy promotes safe, effective, and high-quality care.
Descriptors: Pressure Ulcer. Continuous Positive Airway Pressure. Infant, Premature. Neonatal Nursing. Intensive Care Units, Neonatal.

RESUMO

Objetivo: Identificar as evidências científicas quanto aos cuidados preventivos de lesão por pressão relacionada ao uso de ventilação não invasiva em recém-nascidos prematuros.
Método: Revisão sistemática da literatura, realizada nas bases PubMeb/Medline, EMBASE, Scopus, *Web of Science*, CINAHL-EBSCO e LILACS via Biblioteca Virtual de Saúde. Foram incluídos ensaios clínicos randomizados controlados, sem restrição de idiomas e sem recorte temporal. A qualidade metodológica foi avaliada por meio do sistema *Grading of Recommendations Assessment, Development and Evaluation*, e o risco de viés por meio da *Revised Cochrane risk-of-bias tool for randomized trials*.
Resultados: A busca identificou nove ensaios clínicos randomizados, publicados em inglês, entre os anos de 2010 e 2021. A maioria dos estudos foi classificada com alta qualidade de evidência. Todos realizaram alocação aleatória e com baixo de risco viés.
Conclusão: Evidências de alta qualidade recomendam a adoção da rotação sistêmica entre máscara e pronga nasal, associada ao uso de barreira protetora com hidrocoloide, como intervenção preventiva prioritária para reduzir as lesões por pressão em prematuros submetidos à ventilação não invasiva. Integrada à inspeção diária da integridade da pele e à manutenção adequada da umidificação, essa estratégia promove um cuidado seguro, eficaz e de alta qualidade.
Descritores: Lesão por Pressão. Pressão Positiva Contínua Nas Vias Aéreas. Recém-Nascido Prematuro. Enfermagem Neonatal. Unidades de Terapia Intensiva Neonatal.

RESUMEN

Objetivo: Identificar evidencia científica sobre el cuidado preventivo de las lesiones por presión relacionadas con el uso de ventilación no invasiva en recién nacidos prematuros.
Método: Revisión sistemática en las bases de datos PubMeb/Medline, EMBASE, Scopus, Web of Science, CINAHL-EBSCO y LILACS. Se incluyeron ensayos clínicos controlados aleatorizados, sin restricciones de idioma ni marco temporal. La calidad metodológica se evaluó utilizando el sistema de Clasificación de Recomendaciones, Evaluación, Desarrollo y Valoración, y el riesgo de sesgo se evaluó utilizando la herramienta Cochrane revisada de riesgo de sesgo para ensayos aleatorios.
Resultados: La búsqueda identificó nueve ensayos clínicos aleatorizados, publicados en inglés, entre 2010 y 2021. La mayoría de los estudios fueron clasificados como de alta calidad de evidencia. Todos realizaron asignación aleatoria y con bajo riesgo de sesgo.
Conclusión: La evidencia de alta calidad recomienda la adopción de la rotación sistémica entre mascarilla y cánula nasal, asociada al uso de una barrera protectora con hidrocoloide, como intervención preventiva prioritaria para reducir las lesiones por presión en prematuros sometidos a ventilación no invasiva. Integrada con la inspección diaria de la integridad de la piel y el mantenimiento adecuado de la humedad, esta estrategia promueve una atención segura, eficaz y de alta calidad.
Descriptores: Úlcera por Presión. Presión de las Vías Aéreas Positiva Contínua. Recien Nacido Prematuro. Enfermería Neonatal. Unidades de Cuidado Intensivo Neonatal.

INTRODUCTION

Preterm newborns (PTNB) are those who are born before completing 37 weeks of gestational age (GA). They are subdivided into late preterm, born from 34 to 36 weeks and 6 days, and extreme preterm, born before 28 weeks [1-3]. Worldwide, prematurity is the leading cause of death among children under 5 years of age. However, there has been a noteworthy decrease in prematurity mortality rates, especially in extreme preterm infants, due to advances in neonate intensive care [4-6]. The Neonatal Intensive Care Unit (NICU) is an appropriate therapeutic environment to diagnose, treat, rehabilitate, and mature the PTNB[7].

The third trimester of pregnancy is remarkable due to fast fetal development. When the baby is born preterm, their main vital organs are yet to be completely formed. The respiratory system still has underdeveloped alveoli and thus has little volume; and pulmonary vascular development is harmed, leading to troubled breathing[8]. In this context, non-invasive ventilation (NIV) has an essential role to provide respiratory support to the PTNB[9].

Support using the NIV as a modality of continuous positive airway pressure (CPAP) is used due to the respiratory immaturity of the preterm infant. Its administration using masks or nasal prongs constantly exerts transpulmonary oxygen (O2) pressure during a respiratory cycle, avoiding the complete elimination of O2 by managing the functional residual capabilities, increasing stability and interalveolar pressure, and culminating in pulmonary maturation and rehabilitation[10].

The short nasal prong CPAP is less invasive, less costly to the health service, and reduces the risks for infections and the number of intubations. It also improves neonate neurodevelopmental results by reducing unnecessary stimuli and handling[11]. Its risks include pneumothorax, abdominal distension, nostril dilation, and rupture of the nasal skin or mucosa[12].

Nasal trauma on the columella and nasal septum is due to the immature vascularization, the anatomy of the region, and the model of interface positioning, coupled with increased pressure in the region[8,9,13,14]. The causes of pressure injury (PI) are multifactorial. It takes place on the skin and near soft tissues, generally over bony prominences or related to the use of medical devices. It can cause skin dryness, erythema, skin rupture, and other issues, with the presence of pain[15,16]. It is a result of pressure on the site of the injury, associated with friction, shear, and later ischemia. Its stages are classified as I, II, III, IV, non-classifiable, and deep tissue pressure injury [15].

When the PTNB is routinely exposure of procedures, equipment, and medical devices, especially considering the vulnerability of their skin, there is a high risk of adverse events[13, 17,

[18]. Here, we understand medical devices as those used for diagnostic and/or therapeutic ends during health care[19]. Nursing care must provide nasal CPAP care to preterm infants, periodically inspecting their skin based on clinical experience in the management of its several interfaces, while also preventing adverse events[20].

Prevention is essential for nursing care and the preservation of health. Thus, conducting research on interventions capable of preventing PIs related to medical devices (RDM) in PTNB helps reduce the incidence of these injuries and their complications. In order to improve neonatal care, this study aimed to answer: What are the effects of preventive care related to pressure injuries caused by the use of nasal CPAP in PTNB?

Considering the existence of RDM PI in preterm infants, identifying preventive care in scientific evidence allows consolidating the knowledge available, which is essential to subsidize the standardization and implementation of effective interventions in clinical practice, focusing on the quality and safety of neonatal care.

Our goal, therefore, was to find scientific evidence about the preventive care against pressure injuries related to the use of non-invasive ventilation in preterm newborns.

METHOD

This is a systematic review of the literature carried out according to the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions[21]. The study was carried out after its protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) under number CDR42022321919.

A systematic review about preventive care against pressure injuries in preterm infants submitted to non-invasive ventilation is essential for the development of care technologies aimed at preventing these injuries and associated complications. It is noteworthy that we could not identify any ongoing or finished research protocol published in PROSPERO or in the Cochrane Library of Systematic Reviews.

The research question was created using the acronym PICOS, where P is for population/problem; I for Intervention; C for comparison; O for outcomes; and S for Study design [21,22]. For this study, the Population/problem were preterm newborns hospitalized in NICU and using nasal CPAP; the Intervention was the preventive care against nasal CPAP injuries; the Comparison was made between a control and an intervention group; the Outcome was prevention and reduced number of lesions; and as for Study design, we considered controlled randomized, non-randomized, and quasi-experimental clinical trials. The resulting

question was: What are the effects of preventive care in the prevention of pressure injuries related to the use of nasal CPAP in preterm newborns?

The research was conducted in the following databases: the journal database of the Coordination for the Improvement of Higher Education Personnel (CAPES); PubMeb, via Medical Literature Analysis and Retrieval System Online (MEDLINE); EMBASE; Scopus; Web of Science (WoS); Cumulative Index to Nursing and Allied Health Literature (CINAHL-EBSCO); and Latin American and Caribbean Literature in Health Sciences (LILACS) via Virtual Health Library (VHL).

This review included clinical randomized controlled trials (blinded, double-blind, triple-blind). Were excluded: studies that did not detail preventive interventions against PI related to nasal CPAP, uncontrolled trials and observational studies (ecological, cohort, case-control, editorials, comments, reviews, and qualitative research). There were no restrictions regarding language or specific time frames for the studies analyzed, in order to expand the diversity of our findings.

We used controlled descriptors available at the Health Science Descriptors (DECS) and Medical Subject Headings (MeSH), in association with the Boolean operators AND and OR. Considering the specificities of each database, we established a strategy/search equation. Seen as equation 1 did not lead to a significant number of articles, we decided to combine them to improve our search results. Thus, we made the combinations 1, 2, 3, and 4, using parentheses, brackets, quotation marks, and others, as table 1 shows.

Table 1 - Description of the search strategy in the database. Iguatu, Ceará, Brazil, 2022

	Description	
#1	"Infant, Premature" [MeSH Terms] OR "Premature Infant" [Text Word] OR "Preterm Infants" [Text Word] OR "Infant, Preterm" [Text Word] OR "Infants, Preterm" [Text Word] OR "Preterm Infant" [Text Word] OR "Premature Infants" [Text Word] OR "Neonatal Prematurity" [Text Word] OR "Prematurity, Neonatal" [Text Word] OR "Birth, Premature" [Text Word] OR "Births, Premature" [Text Word] OR "Premature Births" [Text Word] OR "Preterm Birth" [Text Word] OR "Birth, Preterm" [Text Word] OR "Births, Preterm" [Text Word] OR "Preterm Births" [Text Word]	
#2	"Delivery of Health care" [MeSH Terms] OR "Healthcare Deliveries" [Text Word] OR "Healthcare Delivery" [Text Word] OR "Deliveries, Healthcare" [Text Word] OR "Delivery, Healthcare" [Text Word] OR "Health Care Delivery" [Text Word] OR "Delivery, Health Care" [Text Word] OR "Injuries and Wounds" [Text Word] OR "Wounds and Injury" [Text Word] OR "Injury and Wounds" [Text Word] OR "Wounds, Injury" [Text Word] OR "Pressure	

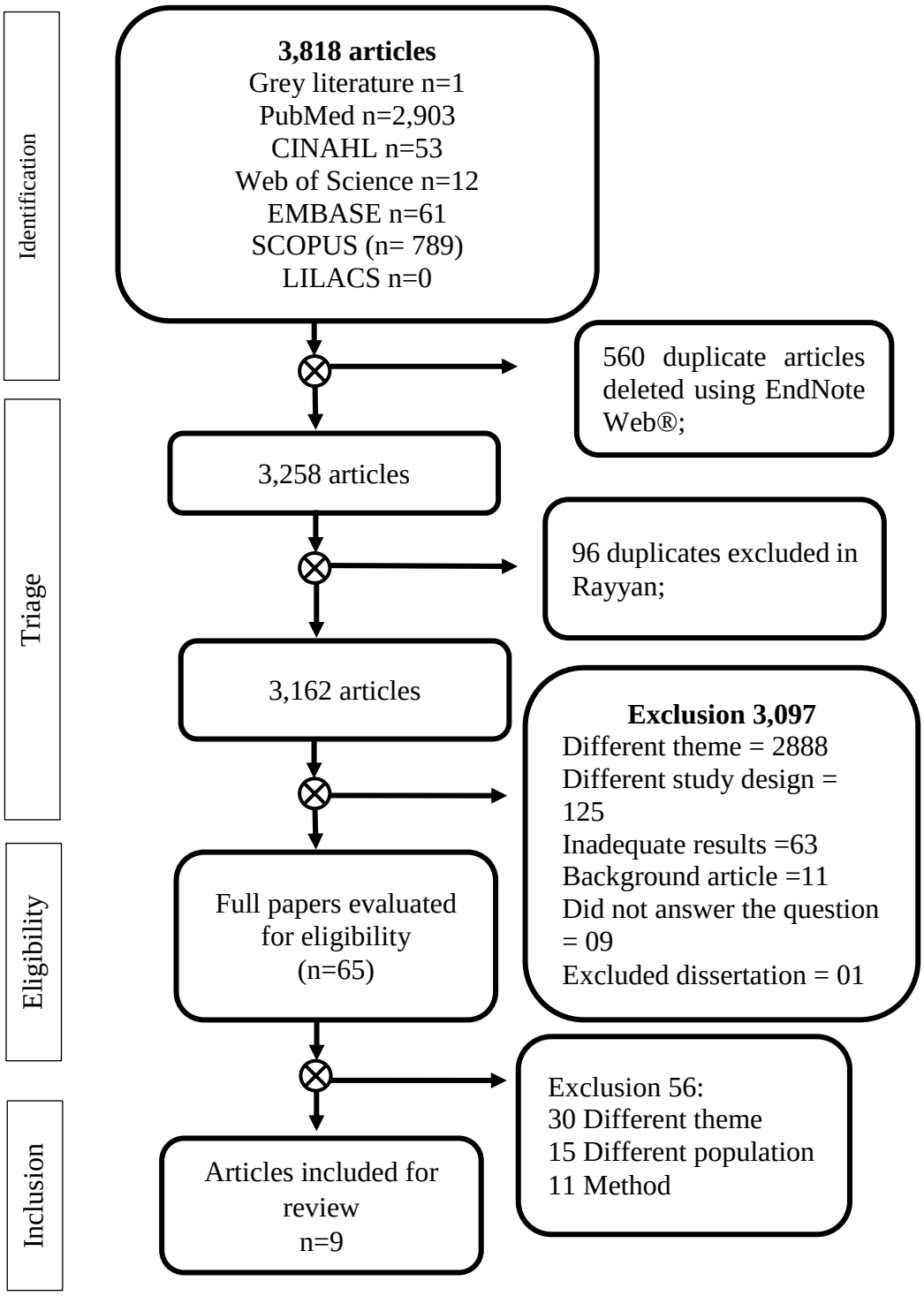
	Ulcers" [Text Word] OR "Ulcer, Pressure" [Text Word] OR "Ulcers, Pressure" [Text Word]	
#3	"Critical Care" [MeSH Terms] "Care, Critical" [Text Word] OR "Intensive Care" [Text Word] OR "Care, Intensive" [Text Word]	
#4	Equipment and supplies"[MeSH Terms] OR "Apparatus and Instruments" [Text Word] OR "Instruments and Apparatus" [Text Word] OR "Continuous Positive Airway Pressure" [MeSH Terms]; Supplies and Equipment; "CPAP Ventilation" [Text Word] OR "Ventilation, CPAP" [Text Word] OR "Nasal Continuous Positive Airway Pressure" [Text Word] OR "nCPAP Ventilation" [Text Word] OR "Ventilation, nCPAP" [Text Word]	
Equation 1	#1 AND #2 AND #3 AND #4	TOTAL 205
Equation 2	#1 AND #2 AND #3	3030
Equation 3	#1 AND #2 AND #4	583
Sum of the results of the equations	EQUATION 1 RESULTS + EQUATION 2 RESULTS + EQUATION 3 RESULTS =	3818

Source: The authors, 2022.

As for the search in LILACS, owing to the fact it is a database with articles in Portuguese, we used descriptors in Portuguese from DeCS (Health Science Descriptors) , namely: *"Recém-nascido", "Lesão por Pressão", "Ferimentos e Lesões", "Prestação de cuidados de saúde Cuidados Críticos"; "Unidades de Terapia Intensiva Neonatal"*, with their respective synonyms, and associated using the Boolean operators AND and OR.

The consequent search in the databases is illustrated in Figure 1, which detailes the identification, triage, eligibility, and inclusion processes[23].

Figure 1 -Flowchart for the identification and selection of studies in the systematic review using the Preferred Reporting Items for Systematic Review and Meta-Analyses[23].



Source: The authors, 2022.

The articles found in the databases were exported into EndNote Web® (Clarivate Analytics PA, USA), where duplicates were removed. Later, they were input into the software Rayyan® (Qatar Computing Research Institute, Doha, Qatar). The search was carried out in February 2022 and updated in January 2024.

The process of searching, selecting, and evaluating the studies was carried out by two reviewers. When they disagreed, a third reviewer was consulted. In the first stage, a triage of the studies was conducted, including an independent reading of their titles and abstracts. In the second stage, reviewers analyzed the differences and similarities of the studies included, reading them in full and having a consensus meeting.

Data collection was carried out using an instrument elaborated according to the guidelines from Cochrane Collaboration[21], including the variables: identification of the study (author(s), title, journal, year of publication), objectives and method (randomization, blinding, allocation sequence, sample size, inclusion and exclusion criteria, intervention and control groups, data analysis, and outcome)[21]. We also gathered further information from the studies, including country, database consulted, place of intervention, justification, clinical profile, sex, age, and ethnicity. Regarding PI characterization, we also included data about whether the PI was related to the use of nasal CPAP, and on interventions to prevent PI, such as type of intervention, indication of intervention/care, contributions, and time or permanence of the intervention.

It was not possible to carry out a meta-analysis due to the lack of homogeneity of procedures and methodological differences, such as: the corrected age of the newborn, association measures, comparison, and intervention groups, differences in clinical outcomes, and different forms of care. Therefore, this review presents a descriptive analysis of evidence.

The methodological quality was evaluated using the system Grading of Recommendations Assessment, Development and Evaluation (GRADE) to measure the quality of evidence, the force of recommendation, and risk of bias considering the revised Cochrane Risk-of-Bias tool for randomized trials (RoB 2.0) [24,25]. RoB 2 has seven domains, which are: random sequence generation, allocation concealment, blinding of participants, blinding of outcome assessors, incomplete outcomes, selective outcome reporting, other sources of bias[25].

This helps classify the trials as having a "low risk of bias" and a "low general risk of bias", while others may show a "high general risk of bias". The GRADE online was also used to determine the strength of the recommendations for health care, which was classified as "high", "moderate", "low", or "very low"[24,25].

RESULTS

Our findings are presented in descriptive form, using images and tables. The search found nine (9) studies, all of which were randomized clinical trials and answered the research question. Nine of them were written in English. As for their country of origin, three were from

India (E1, E5, E8) and two from Iran (E3, E7); Australia (E2), Brazil (E4), Turkey (E6), and the United States (E9) presented one article each. All articles were published in international journals from 2010 to 2021. Some years stood out as having two papers each, namely: 2017 (E5, E7) and 2020 (E3, E8).

Table 2 shows the characterization of the studies in this review.

Table 2 – Descriptive synthesis of the nine studies included in the systematic review. Iguatu, Ceará, Brazil, 2022

Study Author Journal Country	Objective	Technique Control group Intervention Group	Results	Recommendations
E1 Bashir *et al.*, (2019) [26] PLoS one. India	To evaluate the incidence and severity of nasal injuries from the use of nasal CPAP with two different nasal interfaces in three groups (alternating group, continuous mask group, and prong group).	Intervention Group Systemic alternation (alternating between mask and prong) (n=58) Control group Prong (n=60) Mask (n=57)	The continuous use of the mask to remove the nasal CPAP presented lower incidence (33.3%) and severity of nasal lesions (median score of 0) when compared to the Alternating (56.9%, score of 1) and Continuous prong (91.6%, score of 3) groups, with a statistically significant difference (p 0.0001). These results indicate that the continuous use of a mask can be more effective in reducing nasal lesions in neonates.	To prioritize the use of nasal masks; Systemic alternation: Alternate use between mask and nasal prong.
E2 Collins *et al.*, (2014) [27] *EurJ Pediatr* Australia	To compare the incidence of nasal trauma in preterm infants with <32 gestation weeks, randomized for airway pressure (NCPAP) or humidified heated high-	Intervention Group Nasal CPAP group: Sticky Whiskers® wound dressing (n=32) Cannualaide ® (hydrocolloid dressing) (n=33)	The study showed that babies who received HHHFNC showed less nasal trauma in the first 7 days after extubation (mean score of 2.8) when compared to the babies who received NCPAP (mean score of 11.7) (p>0.001). Regarding nasal dressings, there was no significant difference	To use instruments, scales, and injury classification in preterm infants; Humidify the nasal CPAP to maintain the integrity of the nasal mucosa.

	flow nasal cannulas (HHHFHNC) in the first 7 days after extubation and evaluate the effect of two different nasal wound dressings in the children under NCPAP.	Control group High Flow Group: Sticky Whiskers® dressing only (n=67)	between babies under NCPAP using Sticky Whiskers® (14.4) or Cannualaide® (9.5) (p = 0.06).	
E3 Rezaei *et al.*, (2021) [28] *Advances in skin and wound care* Iran	To investigate the effects of a nasal protective wound dressing on the incidence and severity of nasal lesions in preterm babies who received N-CPAP	Intervention group: Use of hydrocolloid dressing (n=40) Control group Placebo (n=40)	The babies in the intervention group (would dressing to protect the nose) presented a significantly lower incidence and severity of nasal lesions when compared to the control group (37.5% vs. 92.5%; P < 0.001). Most lesions varied from mild to moderate, with only three severe lesions in the intervention group and five in the control group.	To use a protective barrier on the skin of the newborn; To use hydrocolloid.
E4 Ribeiro *et al.*, (2020) [29] *Heliyon* Brazil	To compare the efficacy of hydrocolloid and siliconee gel in the nasal protection of the newborn under non-invasive ventilation (NIV).	Intervention Group Hydrocolloid dressing (n=11) Control group Thin siliconee dressing (n=11) Thick siliconee dressing (n=11)	The hydrocolloid showed fewer nasal lesions (36.36%) when compared to the thick (81.81%) and the thin (72.72%) siliconee dressings (p=0.06). Although the stage of the injury was not significantly difference, the hydrocolloid adhered better to the skin of the newborns (p=0.03).	To use a protective barrier on the skin of the newborn; To use hydrocolloid. To inspect the newborn skin daily, especially on the nose; to evaluate the pressure points of the CPAP interface.

E5 Chandrasekaran *et al.*, (2017) [30] *Eur J Pediatr* India	To compare the efficacy and safety of continuous positive airway pressure (CPAP) using nasal masks with bi-nasal prongs.	Intervention Group Mask Interface (n=37) Control group Nasal prongs (n=35)	The study showed that the incidence of nasal trauma of any degree in the first 72 hours was similar between nasal mask groups and binasal prongs (RR 1.07, 95% CI 0.84-1.35, p = 0.59). However, the incidence of severe nasal trauma (grade II/III) was significantly lower in the nasal mask group (0% vs. 31%, p < 0.001).	To use a protective barrier on the skin of the newborn; To use hydrocolloid. To prioritize the use of the nasal mask, as opposed to the prong.
E6 Günlemez *et al.*, (2010) [31] *Indian Pediatrics* Turkey	To investigate the efficacy of applying silicone gel on the nostrils to prevent nasal lesions in preterm infants receiving ventilation with continuous positive airway pressure (CPAP).	Intervention Group Use of siliconee gel tape (n=92) Control group Placebo (n=87)	The study showed that the use of a siliconee gel tape on the nostrils significantly reduced ($p<0.05$) the incidence of nasal lesions in preterm infants under CPAP ventilation. The incidence was 14.9% in Group 1 (no silicone gel tape) and 4.3% in Group 2 (with silicone gel tape) (OR: 3.43; $p<0.05$). Columella necrosis occurred in 6 group 1 patients (6.8%) and 1 group 2 patient (1.08%) (OR: 6.34; $p<0.05$) The mean time until the lesion developed was shorter in Group 1 (10.8 ± 3.1 days) than in Group 2 (16.2 ± 3.2 days, $p<0.05$). The length of the CPAP treatment was identified as the main risk factor for nasal lesions, with lower weight at birth and gestational age being significant risk factors ($p<0.001$).	To use siliconee gel (protective barrier).

E7 Jabraeili *et al.*, (2017) [32] *Int J Pediatr* Iran	To investigate the efficacy of an evidence-based clinical care protocol to ensure the integrity of preterm infants that receive nasal CPAP.	Intervention group: Nasal skin care protocol (n=55) Control group Routine care (n=55)	The intervention group, which followed the evidence-based protocol for nasal skin care, had significantly lower NSCS scores than the control group under routine care (p=0.000), indicating that the care protocol was effective to protect nasal skin.	To use protocols to prevent lesions in preterm infants.
E8 Maram *et al.*, (2021) [33] *Scientific Reports* India	To compare a RAM cannula with Cannulaide versus a Hudson prong for the reduction of nasal lesions in preterm infants born with 28 to 34 weeks of gestational age and weighing ≥1000g and using nasal CPAP.	Intervention Group Prongs (AMR cannula) with hydrocolloid dressing (n=112) Control group Prongs (Hudson pins) (n= 117)	The RAM cannula with cannulaide showed a lower incidence of nasal lesions when removing the CPAP, in comparison with the Hudson prong (6% vs. 26.4%; p = 0.0001). The incidence of moderate to severe injuries and the need for mechanical ventilation, as well as the length of oxygen use and the need for nasal CPAP for 3 days or more, were similar between the groups.	To use a protective barrier on the skin of the newborn; To use hydrocolloid.
E9 Newnam *et al.*, (2015) [34 *Applied Nursing Research* United States	To identify differences in the frequency and severity of injuries when comparing the different CPAP interfaces used to treat respiratory distress syndrome. To describe the risk factors associated with injuries and skin ruptures during the use of nasal CPAP.	Intervention Group: Systemic alternation (alternating between mask and prong) (n=22) Control Group: Nasal prong (n=21) Mask: (n=35)	24.2% of the infants presented skin lesions during CPAP use, mostly affecting the nasal septum (85.3%). There were no significant differences between the location of the lesions between the groups. The mean weight of the babies and the CPAP flow influenced the injuries (p = < 0.001 and p = 0.037). Erythema (p < 0.001) and excoriation (p = 0.007) were less common and severe in	Systemic alternation: Alternate use between mask and nasal prong.

			the alternating group, when compared to the nasal prong and nasal mask groups.	

Source: The authors, 2022.
Caption: CPAP - Continuous Positive Airway Pressure.
Heated Humidified High Flow Nasal Cannulas (HHHFNC)
Neonatal Skin Condition Scale (NSCS)

The number of participants in the studies varied from 33 to 229, with three studies (E1, E4, E9) dividing participants into three groups. For five studies (E1, E4, E6, E8, E9), the primary outcome was related to the context of nasal trauma, considering the incidence and severity of the nasal injury. Only one study (E2) discussed the incidence of the problem. In three studies (E5, E6, E7), nasal trauma was the secondary outcome.

Regarding CPAP care, the following stood out: skin barrier associated with air humidification and heating (E1), care protocol (E7), pins for fixation of the CPAP device (E8), and application of Neonatal Skin Condition Score (E9). Regarding skin protective barriers: hydrocolloid skin barrier (E1, E2, E3, E4, E8) and silicone gel tape (E4, E6). Hydrocolloid dressings (E3, E4, E8) were effective in reducing the frequency and severity of injuries, in addition to being cost-effective.

Regarding the prevention of lesions using the nasal CPAP, three studies (E1, E5, E7) suggested that the incidence and severity of PI is lower with the use of masks, when compared to nasal prongs. Three other studies (E1, E7, E9), however, suggested that alternating between prong and mask reduces the frequency of PI when compared to the use of only one of these methods.

The main types of care were evaluated using the GRADE system to ascertain the quality of evidence. The system indicated a high reliability in many types of care, namely: the alternation of mask and prong (E1, E9); the use of a protective barrier on the skin of the PTNB (E3, E3, E5, E8); the use of hydrocolloid (E3, E4,E5, E8); daily inspection of the skin of the PTNB, especially of the nose; evaluating the pressure points of the CPAP interface (E4); prioritizing the use of a nasal mask, as opposed to that of a prong (E1, E5, E9); using instruments, scales, and classifications of injury in premature infants (E2); and humidification of nasal CPAP to maintain the integrity of the nasal mucosa (E2). Additionally, the use of

silicone gel dressings (E6) as a protective barrier presented a moderate level of reliability, according to the GRADE system.

Regarding the quality of evidence, according to the GRADE, four studies were classified as having a high evidence level (E1, E5, E8, E9), while one had moderate (E6) and one had a very low (E7) evidence levels. In two articles (E6, E7), the domains of risk of bias and inconsistency received the lowest score, which dragged down the evidence quality, as table 3 shows.

Table 3 - Evaluation of the quality of evidence according to the domains established by the Grading of Recommendations Assessment, Development, and Evaluation [24,25]. Iguatu, Ceará, Brazil, 2022.

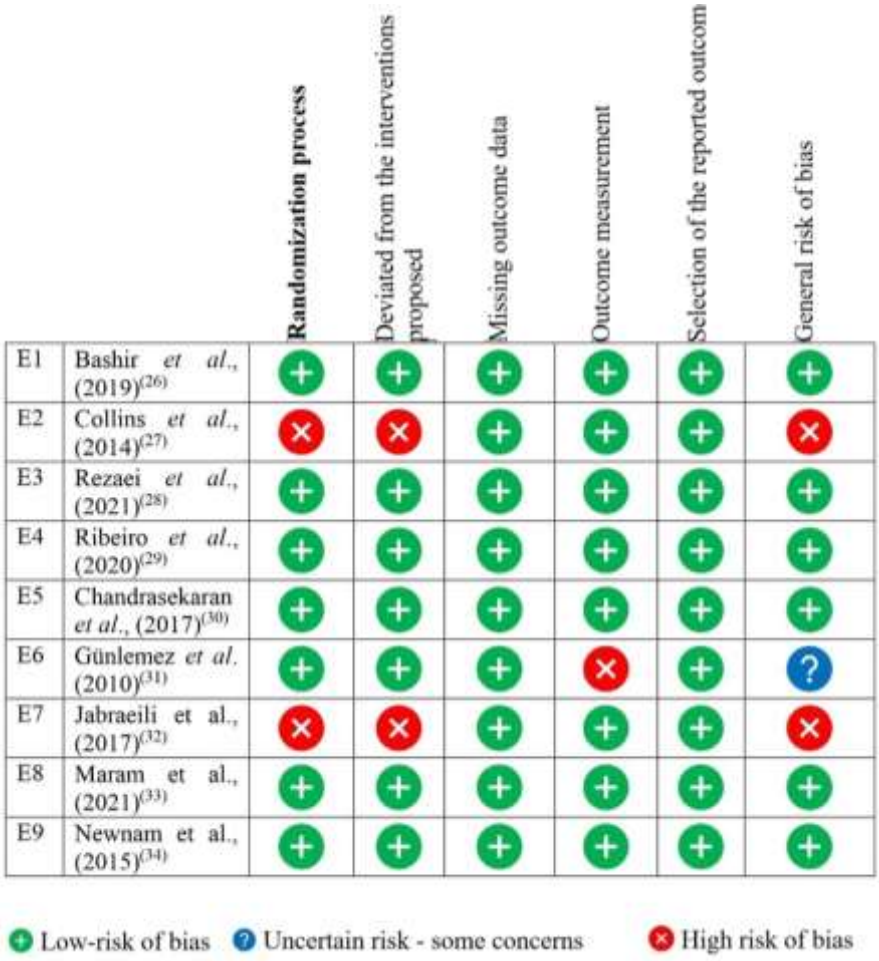
QUALITY ASSESSMENT							**Evidence quality**
No. of the study	Design	Risk of bias	Inconsistency	Indirect evidence	Imprecision	Other considerations	
E1	RCT	not severe	not severe	not severe	not severe	none	⊕⊕⊕⊕ High
E2	RCT	not severe	not severe	not severe	not severe	none	⊕⊕⊕⊕ High
E3	RCT	not severe	not severe	not severe	not severe	none	⊕⊕⊕⊕ High
E4	RCT	not severe	not severe	not severe	not severe	none	⊕⊕⊕⊕ High
E5	RCT	not severe	not severe	not severe	not severe	very strong association	⊕⊕⊕⊕ High
E6	RCT	severe [A]	not severe	not severe	not severe	none	⊕⊕⊕◯ Moderate
E7	RCT	very severe [D]	very severe [B]	not severe	not severe	highly suspicions for publication bias [C]	⊕◯◯ Very low
E8	RCT	not severe	not severe	not severe	not severe	none	⊕⊕⊕⊕ High
E9	RCT	not severe [C]	not severe	not severe	not severe	none	⊕⊕⊕⊕ High

Source: The authors, 2022.
Caption: Randomized clinical trial (RCT).
A. No description of blinding
B. Study does not present data about sample allocation, with an incomplete and selective report of the data.
C. Data was not present in the way it should considering the goals proposed (in tables, graphs, and charts).
D. There was no description of blinding and randomization.

As for the quality of evidence, all studies were randomly allocated. Seven (E1, E2, E4, E5, E6, E8, E9) were classified by the Evidence Level scale (35,36) as 1b and two (E3, E7) were classified as 2b.

Regarding the risk of bias, as evaluated by RoB 2, five studies (E1, E3, E5, E8, E9) were classified as having a low risk of bias, one (E6) as having an uncertain risk (some concerns), and two as having a high risk (E2, E7)[25]. The high risk of bias classifications in some domains were related to the randomization process (E2, E7). Two (E2, E7) showed deviations in their intended interventions, and one (E6) in its outcome measurement, according to Figure 2.

Figure 2 - Individual assessment of the risk of bias of Randomized Controlled Clinical Trials, according to the revised Cochrane Risk-of-Bias tool for randomized trials [25]. Iguatu, Ceará, Brazil, 2022



Source: The authors, 2022.

DISCUSSION

The immaturity of the preterm newborn pulmonary system means that they require ventilatory support. Oxygenation with positive airway pressure is one of the most used treatments to the Respiratory Distress Syndrome (RDS) in the neonate period. Nasal CPAP is

the less invasive option, but presents a risk of injury to the nasal septum, columella, and nostrils with the use of prongs. Safe care requires a careful evaluation to manage the device and choose the oxygen provision interface during treatment[37].

The medical device being used may cause skin injuries, and its choice is important to prevent adverse events and health issues in the newborn, medical device-related pressure injury (MDRPI)[37], since the PTNB skin is more vulnerable to the development of injuries, even under minimal pressure, a situation made even worse in the case of extreme preterm infants[38].

The main interfaces of CPAP provision are the facial mask and the prongs (single short nasal prong, nasopharyngeal prong, and short nasal prong). Nasal prongs, when compared to the masks, are significantly associated with a higher incidence of nose skin rupture (E1, E5, E8, E9)[26,30,33,34]. The most likely sites for the development of injuries are the nasal septum, followed by the columella and the nostrils (E1, E4, E7)[25,28,32].

Corroborating these findings, the most commonly used type of CPAP is via short nasal prongs, which are installed early to treat respiratory difficulties in newborns[10,39]. The characteristics of the material of the prong, as well as its size and appropriate fixation, are factors that increase the risks of nasal septum lesions. These characteristics must be taken into consideration, since they are among the most common interfaces, considered to be practical, less invasive, and low cost[37]. Therefore, it stands out that three articles recommend using the mask, when compared to the prong, to reduce PI (E1, E5, E9)[26,30,34].

Alternating the use of mask and prong, what is called systematic alternation, significantly reduces the likelihood of nasal injuries (E1, E9), showing efficacy in changes every 8h (E1) and every 4h (E9)[26,34]. This is one of the most recommended procedures, as it favors skin decompression, reducing the risk of developing PI and eventually advancing the lesion[20]. This study found that systemic alternation every 8h was more effective to prevent PI, when compared to continuous use [20]. Furthermore, the study shows the importance of systemic alternation that is not more frequent than every 4h for PTNB weighing less than 1,500g[40].

Alternating the interfaces ensured that pressure on the sites where the device was located changed and reduced the time of pressure on the nasal skin of the preterm infant(E9)[34]. In a review study, systemic alternations helped reduce the pressure points in sensitive areas of the body, such as the nasal septum, nostrils, and other structures of the face[40].

It is worth repeating that skin injuries with the same form or standard of the device being used usually develop in the region of the nose, following the standard PI classification system [41,42]. Thus, ensuring ideal humidification is important to maintain the integrity of the

respiratory mucosa (E1, E3, E7, E9)[26,28,32,34]. All air inspired must be at 37ºC and 100% humidity; the intensity of the airflow, especially when it is not humidified, leads to dryness in the nose and the resulting formation of thick secretions[43].

Regarding protective covers and dressings, this study showed that hydrocolloid dressings protect against the rupture of nasal skin and reduce the incidence and severity of nasal trauma. Other measures would be an appropriate fixation of nasal prongs and the consequent reduction of air leakage (E3, E5, E9), as well as the choice of a dressing, considering weight, form, and size of the nose (E3)[28,30,34].

Decreases in the frequency of PI are related to the potential effects of the hydrocolloid in reducing the attrition between the prong and the nasal septum and columella; the use of a dressing under the devices, in turn, represents a barrier to the skin, reducing pressure and shearing[44]. Although it is effective due to its high adhesiveness, the removal of the hydrocolloid must be done with care, to avoid trauma to the nasal skin of the PTNB (E4)[29]. Although the studies recommend its use to prevent lesions, there is scarce evidence regarding how best to remove it.

To remove the hydrocolloid, the skin under it must be lightly pressured, while its edges are slightly raised; thus, all sides can be detached, and it can be carefully removed. The dressing should be exchanged as soon as it starts to detach, the stage of the lesion changes, or according to recommendations[29].

The silicone gel tape was seen as a protective factor against MDRPI, if compared to the hydrocolloid plate in the use of double pronged CPAP (E6)[31]. It is an elastomeric adhesive membrane, which has polydimethylsiloxane with variable concentrations in its composition. This ensures that the material is soft and flexible, helping prevent PI and protecting the nasal base when using prongs[29].

Despite its efficacy, the silicone gel tape must be periodically replaced due to the low adherence and ease with which it becomes detached, changes in the protective barrier and the need to evaluate the lesion and its stage[31]. In cases where the PI is identified and an intervention starts early, the places in which the device exerts pressure should be periodically inspected (E4, E7)[29,32]. This daily inspection strongly contributes to reducing the effects of lesions by enabling fast actions/decisions to be taken about the injury[45].

Thus, the places that must be observed with greater care in the nasal physical examination are: nostrils, columella, nasal septum, filter, and tip of the nose (E7)[32]. An evaluation that goes beyond the nasal area is also recommended, focusing on the temporozygomatic and parieto-occipital-temporal regions [46].

Daily evaluations in the care of PTNB commonly measure the nasal lesion using standardized scores. For the precise prevention, identification, and treatment of nasal lesions, one must adopt evaluation tools and classify its stage (E1, E2, E3, E8)[26,27,28,33].

This review also showed the use of the Neonatal Skin Condition Score (E7, E9), due to the fact its use allows evaluating the skin condition of the PTNB. Developed in the United States and validated for use in Brazil in 2012, the Neonatal Skin Condition Score (ECPRN) is an intervention to prevent PI in preterm children (E7, E9)[32,34,47].

Therefore, the clinical management of extreme preterm babies using nasal CPAP must be supported by evidence-based practices (E1, E7)[26,32]. The use of practical, evidence-based clinical practices significantly reduces nasal skin damage to preterm babies using CPAP.

This review included studies that showed measures of prevention and care that allowed the nurse to act towards preventing MDRPI in preterm infants. Its limitations include the fact that the studies had different methodologies, sample sizes, patient profiles, and used different forms of prevention and dressings, making it impossible to create a meta-analysis from the data. Further research should seek broader evidence and test other preventive measures and forms of care.

Considering the scientific evidence involving the implementation of care in the clinical decision making process of the nurse, certain strategies to prevent MDRPI stand out, including the systemic alternation between mask and prong, the use of hydrocolloid protective barriers, siliconee gel tapes, and daily and routine inspection of skin humidity, all in tandem with clinical protocols and guidelines with validity evidence.

CONCLUSION

This systematic review allowed identifying the main forms of care for the prevention of pressure lesions related to the use of non-invasive ventilation in preterm newborns, from systematic alternation to the use of protective barriers using hydrocolloid and siliconee gel. In addition, professionals must inspect the skin of the newborn daily, monitoring its humidification and using clinical protocols and guidelines based on robust studies as preventive care tools.

Evidence found showed that alternating between a mask and a nasal prong reduced lesions when compared to the isolated use of each device. Furthermore, the use of barriers to protect the skin, especially hydrocolloid, was superior in terms of cost-benefit, in addition to being more effective than alternatives, such as silicone tape, as a preventive measure.

Therefore, current evidence highlights the need to effectively implement these

interventions in clinical practice, to ensure safe, effective, and quality care.

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Availability of Data and Materials

Access to the dataset may be made upon request to the corresponding author. Part of the data used in this systematic review was from restricted access databases, whose guidelines do not allow their full public availability. Thus, any request will be evaluated according to the licensing terms of the databases consulted and ethical principles of use and disclosure of scientific data.

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