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ORIGINAL PAPER

Breathing safely: eliminating facial injuries related to nonivasive positive pressure ventilation devices

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Abstract

Aim: To evaluate the efficacy of hydrocolloid dressing in preventing stage two or higher facial pressure injuries associated with the use of noninvasive positive pressure ventilation (NIPPV) devices among critically ill patients. *Design:* A randomized control trial. *Methods:* The study included 56 adult patients in intensive care units. The study participants were categorized into two groups consisting of 28 patients in each group. The control group received skincare using a fine mist of water and repositioning of the device every two to four hours, while the intervention group received a hydrocolloid dressing and repositioning of the device every two to four hours. *Results:* A total of 33.9% of all participants in the study had facial pressure injury. None of the patients in the intervention group who received hydrocolloid dressing developed stage two or higher facial pressure injuries. A total of 32.2% of the control group developed stage two or higher facial pressure injuries. Results indicated that the use of hydrocolloid dressing can significantly prevent the formation of stage two or higher facial pressure injuries ($p < 0.001$). *Conclusion:* The study's findings support the use of hydrocolloid dressing as a preventative measure for facial pressure injuries related to NIPPV devices.

Keywords: critically ill patients, facial injuries, hydrocolloid, positive-pressure ventilation, pressure ulcer.

Introduction

Pressure injuries have become a prominent concern across various fields due to the use of monitors, ventilation masks, ventilators, and catheters during hospitalization. These devices, although necessary for the recovery process, have been linked to skin injuries related to patients' conditions (Bhattacharya & Mishra, 2015; Fumarola et al., 2020). In 2014, the National Pressure Injury Advisory Panel (NPIAP) drew attention to this issue and introduced the concept of medical device-related pressure injuries (MDRPIs). The NPIAP defines MDRPIs as injuries that occur as a result of using devices intended and applied for diagnostic or therapeutic purposes (Edsberg et al., 2016).

Noninvasive positive pressure ventilation (NIPPV) devices are effective tools for managing respiratory failure without the need for invasive airways (Winck & Gonçalves, 2011). However, their prolonged use has been associated with facial pressure injuries of all stages (Wei et al., 2023). The injuries result from mask tightness, which increases friction and shear by rubbing the skin, as well as increased humidity beneath mask borders, leading to softening of stratum corneum and increased permeability (Feng et al., 2023). Dry skin may also be a cofactor in injury development due to epidermal stiffness fostering cracks (Lechner et al., 2017). These factors are collectively referred to as microclimates.

Facial pressure injuries are skin or mucosal membrane breakdowns that occur due to NIPPV devices, with a frequency of 26.7%, including 16.7% at stage two (Wei et al., 2023). There are four distinct stages of pressure ulcers that are classified according to depth and tissue involvement. These stages range from non-blanchable erythema (stage one) to full-thickness ulcers (stage four) (Al Aboud & Manna, 2023). Additional research is required to investigate and address the variations in pressure injuries across different regions (Siotos et al., 2022).

Facial pressure injuries not only have significant

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economic burdens but also affect the psychological well-being of both patients and caregivers. The treatment of hospital-acquired pressure injuries amounts to an economic burden of more than 26.8 billion United States dollars per year in the United States. Additionally, facial pressure injuries cause pain, anxiety, emotional distress for patients and caregivers, and can decrease treatment tolerance and comfort, ultimately impeding recovery. This has been demonstrated in various studies, including Benisco et al. (2019), Etafa et al. (2018), and Schallom et al. (2015).

It is important to note that prevention measures may differ depending on the patient population and the resources available in different healthcare settings. Therefore, it is crucial for healthcare professionals in developing countries to conduct research and evaluate the effectiveness of pressure injury prevention strategies in their specific context. This will not only help to reduce the incidence of pressure injuries but also improve the quality of care provided to patients.

Understanding the incidence and risk factors for facial pressure injuries related to NIPPV devices and evaluating the effectiveness of preventative measures such as hydrocolloid dressing can help reduce the burden of these injuries on patients and healthcare systems.

Aim

This study aimed to evaluate the efficacy of hydrocolloid dressing in preventing stage two or higher facial pressure injuries associated with the use of NIPPV devices in critically ill patients in Jordan. Furthermore, it investigated the association between face mask type, and treatment period on NIPPV and facial pressure injury formation.

Study questions:

- What are the incidences of stage two and above facial pressure injuries related to NIPPV devices among critically ill patients?
- Is there an association between face mask type, and treatment period on NIPPV and facial pressure injury formation?
- Does early use of hydrocolloid dressing on high-pressure areas prevent formation of stage two or higher facial pressure injuries?

Methods

Design

A randomized control trial was performed for the purpose of the study. In addition, we took steps to align our study with the current standards outlined in Consolidated Standards of Reporting Trials (CONSORT) checklists.

Sample

The present study targeted critically ill adult patients using NIPPV devices in medical, surgical, and coronary intensive care units (ICUs). The study population comprised patients admitted to the ICU. Inclusion criteria for the study consisted of adult patients aged 18 years or older, currently receiving care in the ICU, and using medical devices such as continuous positive airway pressure (CPAP) or bilevel positive airway pressure (BiPAP) devices with an oronasal or full-face mask for two or more hours per day. An inclusive sample of ICU patients who fulfilled the inclusion criteria was recruited for the study. Exclusion criteria comprised comatose patients receiving invasive positive pressure ventilation and patients with any existing facial soft tissue injuries.

The study was conducted conveniently in a tertiary hospital in Amman, Jordan that provides a diverse range of medical services, attracting patients from across the country due to its acceptance of various health insurance types and the high quality of medical care provided. Critically ill adult patients in the selected units were recruited for the study from this hospital. Patients who met the inclusion criteria were invited to participate, and written consent was obtained from patients or their legal representatives after selection. The first ICU admission meeting the inclusion criteria was assigned to the intervention group, while the next was assigned to the control group, and so on for all eligible patients.

The sample size for this study was determined using the Power Analysis and Sample Size software (version 22.0.5). The recommended sample size was a minimum of 28 patients per group, with a significance level of 95% and a margin of error of 5%. Simple randomization was used to assign patients to either the intervention or control group.

Data collection

Prior to data collection, the researchers conducted informed consent sessions with potential participants, during which they provided a thorough explanation of the study's purpose, potential risks, and benefits, as well as the study procedures. Once participants had given their informed consent, they were randomly assigned to either the intervention or control group. The researchers provided training to ICU nurses on the application of hydrocolloid dressing on high-pressure areas, including the forehead, nasal bridge, chin,

and cheeks before BiPAP or CPAP use, and on performing skin care every two to four hours for five minutes after device removal in accordance with medical protocols. If nurses had any questions, the researchers were available to provide assistance, given their presence in the ICU.

The control group received standard care, which involved skin care with a fine mist of water and repositioning of the device every two to four hours to alleviate pressure, prior to the use of the NIPPV device. In contrast, the intervention group received skin care with hydrocolloid dressing and repositioning of the device every two to four hours, prior to the use of the NIPPV device.

Trained nurses performed skin inspections under the dressing every two to four hours, while researchers assessed the skin daily after removing the dressing and staged the injury. Dressings were replaced if no changes were observed, and daily reassessment continued until occurrence of injury, change in ventilation method, or discharge home. This was done to identify ischemic injuries resulting from pressure. Data collection occurred between June and November 2020, and the procedure took longer than expected due to the Covid-19 outbreak, resulting in a reduction in patient admissions and the use of invasive ventilation rather than NIPPV devices.

Instrument

The researchers developed a tool to collect data on various aspects related to the study, including patient demographic characteristics, Braden score, treatment duration with NIPPV device, type of mask used, Charlson age-comorbidity index, stage and location of any new soft tissue injury, and type of preventive interventions implemented, such as repositioning every two to four hours and use of hydrocolloid dressing.

Data analysis

The data collected were analyzed using the Statistical Package for Social Science (SPSS V. 26). Descriptive statistics were used to analyze the data, which involved calculating frequencies, percentages, means, and standard deviations for the patient demographic characteristics, facial pressure injury formation, and injury stage. To determine the association between the use of hydrocolloid dressing and the formation of stage two or higher facial pressure injuries, the Mann-Whitney U test was applied. Additionally, the association between the type of face mask (full-face mask versus oronasal mask), treatment period on NIPPV device, and facial pressure injury formation was assessed using the binomial logistic regression test. The calculation involved determining the percentage of patients who suffered from pressure injuries according to international guidelines.

Results

Sample characteristics

During the period of data collection, a total of 800 patients were identified in the medical, surgical, and coronary intensive care units. Table 1 illustrates the flow of patients in both the control and intervention groups. A total of 124 patients were initially recruited for the study, with 62 patients allocated to each group. However, due to factors such as patient discharge and non-seriousness of condition, the sample size was ultimately reduced to 28 patients per group. The demographic characteristics of both the control and intervention groups are summarized in Table 2.

Table 1 Control and intervention group for patients with NIPPV device

Approximately 800 patients found to be in ICUs during the data collection				
Not eligible due to our exclusion criteria	531			
Refused to participate	47			
Withdrawn	42			
Did not participate for other reason	56			
124 patients included in this study	in the control group	62	in the intervention group	62
	discharged	15	did not follow the guidance	12
	removed the device frequently	19	removed the hydrocolloid dressing frequently	22
	28 included in control group		28 included in intervention group	

Table 2 Characteristics of study participants (n = 56)

Characteristics	Intervention Group	Control Group	Total
Age (years) M ± SD	57.39 ± 19.71	66.04 ± 13.18	61.7 ± 17.18
Gender	n (%)	n (%	n (%)
male	13 (46.4%)	16 (57.1%)	29 (51.8%)
female	15 (53.6%)	12 (42.9%)	27 (48.2%)
Length of stay in ICU using NIPPV device	4.86 ± 2.88	3.96 ± 1.91	4.41 ± 2.47
Treatment hours on device			
2 hours per day	1 (3.6%)	4 (14.3%)	5 (8.9%)
3–4 hours per day	5 (17.9%)	6 (21.4%)	11 (19.6%)
> 4 hours per day	22 (78.6%)	18 (64.3%)	40 (71.4%)
Braden score			
mild (> 15)	4 (14.3%)	3 (10.7%)	7 (12.5%)
moderate (13–14)	1 (3.6%)	4 (14.3%)	5 (8.9%)
high (10–12)	20 (71.4%)	15 (53.6%)	35 (62.5%)
severe (≤ 9)	3 (10.7%)	6 (21.4%)	9 (16.1%)
Mask type			
oronasal mask	18 (64.3%)	23 (82.1%)	41 (73.21%)
full-face mask	10 (35.7%)	5 (17.9%)	15 (26.78%)

M ± SD – mean ± standard deviation

The study included 56 participants, with an age range of 20 to 94 years (mean = 61.7, SD = 17.18). Of the participants, 51.8% (n = 29) were male and 48.2% (n = 27) were female. The average length of stay in the ICU while using NIPPV was 4.41 (SD = 2.47) days. The majority of patients (71.4%; n = 40), used the NIPPV device for more than four hours per day, while 19.6% (n = 11) used it for three to four hours per day and only 8.9% (n = 5) used it for two hours per day. The Braden scores of the participants were distributed as follows: 16.1% (n = 9) had severe risk scores, 62.5% (n = 35) had high risk scores, 8.9% (n = 5) had moderate risk scores, and mild risk scores accounted for 12.5% (n = 7) of the participants. Additionally, 41 (73.2%) participants used an oronasal mask, while 15 (26.8%) participants used a full-face mask. The Charlson comorbidity index for all participants was 3.86 (SD = 1.94). The results of the homogeneity test indicated that both groups were homogenous.

Facial pressure injuries associated with NIPPV

According to international guidelines for measuring the stages of pressure ulcers by National Pressure Ulcer Advisory Panel (NPUAP), European Pressure Ulcer Advisory Panel (EPUAP) and Pan Pacific Pressure Injury Alliance (PPIA) (Haesler, 2014), of the 56 participants, 33.9% (n = 19) had facial pressure injuries. Specifically, 17.9% (n = 10) of the participants had stage one injuries, while 16.1% (n = 9) had stage two or higher injuries. In the control group (n = 28), 32.2% (n = 9) of the participants experienced stage two or higher facial pressure injuries. On the other hand, the intervention group, who were treated with hydrocolloid dressing, did not develop stage two or higher facial pressure injuries, as shown in Figure 1. However, we found that the use of hydrocolloid dressing did not completely prevent stage one ulcers, with an incidence of 14.3% in these patients compared to 21.4% in those not using hydrocolloid dressing (Figure 1).

Based on the data presented in Table 3, it was observed that the nasal bridge was the site most commonly affected by NIPPV devices. In the control group (n = 28), 35.7% (n = 10) of the participants had injuries on the nasal bridge. In contrast, in the intervention group, only 10.7% of injuries (n = 3) were located on the nasal bridge. In the control group, the nasal bridge and forehead were the second most frequently affected site, accounting for 10.8% (n = 3) of injuries. Additionally, injuries located on the cheeks accounted for 7.2% (n = 2) of the total injuries in the control group. In terms of the number of injuries per patient, it was found that 79% of affected patients (n = 15) had only one injury, whereas 21% of affected patients (n = 4) had two injuries located at different sites.

Predictors of facial pressure injury

A binomial logistic regression analysis was conducted to examine the relationship between facial pressure injury formation and face mask type (full-face mask versus oronasal mask) and treatment period on NIPPV device. No significant relationship was found between the type of face mask (full-face mask versus oronasal mask) and the occurrence of facial pressure injuries (p = 0.95).

Similarly, the analysis showed that the duration of treatment on the NIPPV device did not have a statistically significant association with the occurrence of facial pressure injuries (p = 0.65).

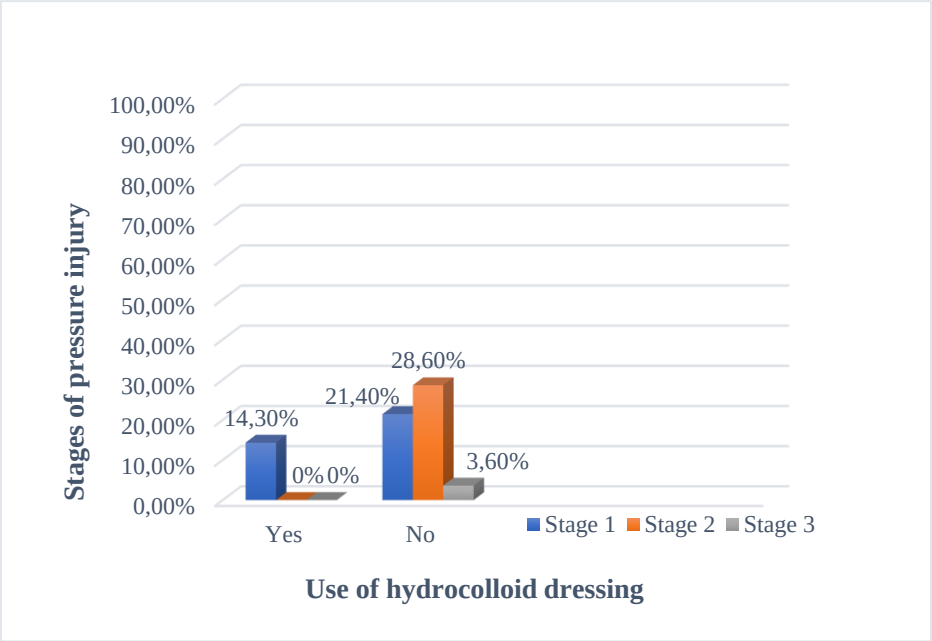

Figure 1 Incidence of facial pressure injuries by group

Table 3 Distribution by treatment group and the anatomical site of pressure injury

Anatomical site	Intervention group used Hydrocolloid dressing n (%)	Control group used Direct mask n (%)	Total n (%)
Nasal bridge	3 (10.7)	10 (35.7)	13 (23.2)
Forehead	1 (3.6)	1 (3.6)	2 (3.6)
Nasal bridge and Forehead	0 (0)	2 (7.1)	2 (3.6)
Nasal bridge and cheeks	0 (0)	1 (3.6)	1 (1.8)
Forehead and cheeks	0 (0)	1 (3.6)	1 (1.8)
Total	4 (14.3%)	15 (53.6%)	19 (33.9%)

Hydrocolloid dressing and facial pressure injuries

In this study, the Mann-Whitney U test was applied to examine the relationship between the use to examine the relationship between the use of hydrocolloid dressing and the formation of stage two or higher facial pressure injuries. We presented the mean scores for each group in relation to the occurrence of stage two or higher facial pressure injuries. The findings of the analysis indicated a significant association between the use of hydrocolloid dressing and the prevention of stage two or higher facial pressure injuries ($p < 0.001$). These results are presented in Table 4.

Table 4 Association between hydrocolloid dressing use and stage two or higher of facial pressure injury

Use of hydrocolloid dressing	Mean	Sum of Ranks	U	Z	P
Intervention group	22.36	626	220	-3.36	0.001**
Control group	34.64	970			

***p < .001; U – Mann-Whitney U test; Z – Z-score; P – value*

Discussion

The study provided empirical evidence supporting the effectiveness of hydrocolloid dressing in preventing stage two or higher of facial pressure injuries related to NIPPV devices among critically ill patients. Among all participants, 16.1% had stage two or higher pressure injuries, which is consistent with a study conducted in Portugal that reported a 16.7% prevalence of stage two or higher pressure injury (Martins et al., 2016). Additionally, 33.9% of our participants had some form of pressure injury, which is consistent with a prior study indicating that approximately 2–50% of patients treated with NIPPV devices experienced pressure injuries (Padula et al., 2019). A 2019 study reported a prevalence of medical device-related

pressure ulcers (MDRPUs) of 19.2% with 20% of these MDRPUs related to NIPPV masks, indicating an alarming prevalence of pressure injuries caused by NIPPV devices (Mehta et al., 2019).

The nasal bridge was identified as the site most commonly affected by NIPPV devices, followed by the forehead, while only two patients had injuries on their cheeks. A study conducted in Spain also reported a high evidence of nasal bridge pressure injury (97.3%) followed by the cheeks (Otero et al., 2017). The reason behind this is likely related to the use of foam padding at the forehead contact point in oronasal face masks in that study compared to our oronasal masks, which contain rigid plastic at the forehead point, leading to greater pressure effects than foam padded masks. A quasi-experimental study conducted on 200 patients found that the nasal bridge was the most frequently affected anatomical site for pressure injury (Schallom et al., 2015). Previous studies have also indicated that the nose and posterior cervical region are common injury sites among patients with NIPPV (Galetto et al., 2019; Boyar, 2020). This is probably due to the fact that the nose is the most prominent bony site on the face and is exposed to high pressure, and the lack of protective fatty tissue on this bone increases the risk of deep tissue injury. These findings support the notion that the site of pressure injury is influenced by bone prominence and the presence of protective fatty tissue, regardless of the type of mask used. It is noteworthy that facial pressure injuries related to NIPPV have a significant impact on patients' quality of life and respiratory needs (Alqahtani & AlAhmari, 2018; Strickland, 2019).

The findings of this study indicate that there was no significant association between the treatment period on NIPPV device and the formation of facial pressure injuries. However, a previous study reported that participants who used NIPPV devices for approximately 18 hours had a higher incidence of pressure injuries than those who used the device for a shorter duration (Martins et al., 2016). In this study, participants were instructed to use the device for no longer than four hours without rest or pressure relief, and to reposition the device every four hours to reduce pressure on the skin, alleviate pain, and improve compliance with treatment, which might facilitate recovery and discharge home. These results are consistent with previous research by Worsley et al. (2016) and align with NPUAP recommendations to reposition the NIPPV device every two-four hours (Edsberg et al., 2016). Reducing the treatment period on NIPPV devices and regular repositioning can help decrease pressure on the skin and improve patient outcomes.

Our study found no association between mask type and the formation of facial pressure injuries related to NIPPV devices. However, a previous study has shown that patients in oronasal mask groups are more likely to develop pressure injuries compared to those in full-face mask groups. In particular, one study found that 20% of patients in the oronasal mask group had pressure injuries, while only 2% of patients in the full-face mask group had such injuries (Tang et al., 2020). In accordance with this finding, the NPIAP recommends the use of full-face masks as an alternative to oronasal masks to distribute pressure more effectively and improve compliance and tolerance of treatment (Deshpande et al., 2016). It is worth noting that in Covid-19 pandemic, front-line healthcare workers have used masks for prolonged periods without significant discomfort or facial injuries being reported (Gasparino et al., 2021).

The use of hydrocolloid dressing on high-pressure areas has been shown to effectively prevent stage two or higher facial pressure injuries, consistent with previous studies (Raurell-Torredà et al., 2017; Tai & Hsu, 2016). Although foam dressing is equally effective, hydrocolloid dressing is more widely available, cheaper, and skin-friendly as it conforms to the natural shape of the face. This is particularly important in developing countries where foam dressing or other types of dressings may be more expensive. The preventative effect is achieved by reducing shear between the mask and skin and maintaining skin moisture under the mask edges. Although research on the role of dressing in preventing facial pressure injuries is lacking, using dressings on high-pressure areas can help prevent or minimize injury formation by prolonging the pressure injury formation process (Jackson et al., 2019). Hydrocolloid dressing is composed of sodium carboxymethylcellulose, pectin, gelatin, and adhesive polymers that help maintain a healthy moist environment and allow for gas exchange necessary for skin health, eliminating skin inflammation or irritation caused by excessive moisture.

Limitation of study

The present study had several limitations that must be acknowledged. One of the most prominent limitations was the relatively small sample size, with only 56 participants enrolled. Another limitation was the use of a single type of protective dressing rather than multiple types, due to the lack of funding for research by organizations and the financial constraints of patients. Consequently, other more expensive types of dressings could not be used, since patients may require multiple dressings daily. Additionally,

the results may have been limited by the method of data collection, which relied on reports from trained nurses in intensive care units regarding the use of hydrocolloid dressing.

Conclusion

The available literature regarding the incidence of facial pressure injuries related to NIPPV devices and the efficacy of preventative interventions is currently limited. In this study, a randomized controlled trial was conducted to address this gap in knowledge and evaluate the use of hydrocolloid dressing in decreasing the incidence of facial pressure injuries resulting from NIPPV device use. The goal of this study was to eliminate preventable harm to patients and enhance their safety and quality of life during hospitalization. The findings suggest that repositioning the mask every four hours and using prophylactic hydrocolloid dressing on high-pressure areas can effectively reduce the formation of stage two or higher facial pressure injuries in critical patients. It is believed that nursing interventions such as skin massages, hydration, continuous assessment, and monitoring, in addition to the use of protective dressing, can help minimize or prevent the formation of facial pressure injuries. Further research is recommended to evaluate the effectiveness of hydrocolloid dressing in preventing facial pressure injuries in patients who use NIPPV devices for more than four hours, and in non-ICU patients, with larger sample sizes, and at other hospitals.

Ethical aspects and conflict of interest

The study adhered to ethical principles and obtained approval from the institutional review board committee (No.10/2020/9605) in the selected hospital before commencement. The researchers followed the guidelines of the Declaration of Helsinki by providing a clear explanation of the study's purpose, potential risks, and benefits to all participants. Furthermore, written consent was obtained from patients or their legal representatives, and the anonymity and confidentiality of the data were ensured. Participants were informed that their participation was voluntary, and they had the right to withdraw at any point during the study without any negative consequences.

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Author contributions

Conception and design (OAA, HSY), data collection (OAA, HSY, LAA) data analysis and interpretation (OAA, HSY, NBR), manuscript draft (OA, HSY), critical revision critical of the manuscript (OA, HSY), final approval of the manuscript (OA, HSY, LAA, NBR).

References

Al Aboud, A. M., & Manna, B. (2023, April, 19). *Wound Pressure Injury Management*. StatPearls. Retrieved April 19, 2023 from https://www.ncbi.nlm.nih.gov/books/NBK532897/

Alqahtani, J. S., & AlAhmari, M. D. (2018). Evidence-based synthesis for prevention of noninvasive ventilation related facial pressure ulcers. *Saudi Medical Journal*, *39*(5), 443–452. https://doi.org/10.15537/smj.2018.5.22058

Benisco, V., Schmidt, R., & Dame, M. (2019). Device related facial pressure injuries (DRFPIs) in respiratory care: a challenge to tackle heads on. *Journal of Business and Behavioral Sciences*, *31*(2), 163–174.

Bhattacharya, S., & Mishra, R. K. (2015). Pressure ulcers: current understanding and newer modalities of treatment. *Indian Journal of Plastic Surgery*, *48*(1), 4–16. https://doi.org/10.4103/0970-0358.155260

Boyar, V. (2020). Pressure injuries of the nose and columella in preterm neonates receiving noninvasive ventilation via a specialized nasal cannula: a retrospective comparison cohort study. *Journal of Wound, Ostomy and Continence Nursing*, *47*(2), 111–116. https://doi.org/10.1097/WON.0000000000000616

Deshpande, S., Joosten, S., Turton, A., Edwards, B. A., Landry, S., Mansfield, D. R., & Hamilton, G. S. (2016). Oronasal masks require a higher pressure than nasal and nasal pillow masks for the treatment of obstructive sleep apnea. *Journal of Clinical Sleep Medicine*, *12*(9), 1263–1268. https://doi.org/10.5664/jcsm.6128

Edsberg, L. E., Black, J. M., Goldberg, M., McNichol, L., Moore, L., & Sieggreen, M. (2016). Revised national pressure ulcer advisory panel pressure injury staging system: revised pressure injury staging system. *Journal of Wound Ostomy and Continence Nursing*, *43*(6), 585–597. https://doi.org/10.1097/won.0000000000000281

Etafa, W., Argaw, Z., Gemechu, E., & Melese, B. (2018). Nurses' attitude and perceived barriers to pressure ulcer prevention. *BMC Nursing*, *17*, 14. https://doi.org/10.1186/s12912-018-0282-2

Feng, L., Zhang, Q., Ruth, N., Wu, Y., Saliou, C., & Yu, M. (2023). Compromised skin barrier induced by prolonged face mask usage during the Covid-19 pandemic and its remedy with proper moisturization. *Skin Research & Technology*, *29*(1), e13214. https://doi.org/10.1111/srt.13214

Fumarola, S., Allaway, R., Callaghan, R., Collier, M., Downie, F., Geraghty, J., Kiernan, S., Spratt, F., Bianchi, J., Bethell, E., Downe, A., Griffin, J., Hughes, M., King, B., LeBlanc, K., Savine, L., Stubbs, N, & Voegeli, D. (2020). Overlooked and underestimated: medical adhesive-related skin injuries. *Journal of Wound Care*, *29*(S3c), S1–S24. https://doi.org/10.12968/jowc.2020.29.Sup3c.S1

Galetto, S. G. d. S., Nascimento, E. R. P. d., Hermida, P. M. V., & Malfussi, L. B. H. d. (2019). Medical device-related pressure injuries: an integrative literature review. *Revista Brasileira de Enfermagem*, *72*(2), 505–512. https://doi.org/10.1590/0034-7167-2018-0530

Gasparino, R. C., Lima, M. H. M., de Souza Oliveira-Kumakura, A. R., da Silva, V. A., Meszaros, M. d. J., & Antunes, I. R. (2021). Prophylactic dressings in the prevention of pressure ulcer related to the use of personal protective equipment by health professionals facing the Covid-19 pandemic: a randomized clinical trial. *Wound Repair and Regeneration*, *29*(1), 183–188. https://doi.org/10.1111/wrr.12877

Haesler, R. (Ed.). (2014). *Prevention and treatment of pressure ulcers: quick reference guide* (3rd ed.). Advisory Panel, European Pressure Ulcer Advisory Panel and Pan Pacific Pressure Injury Alliance. Cambridge Media.

Jackson, D., Sarki, A. M., Betteridge, R., & Brooke, J. (2019). Medical device-related pressure ulcers: a systematic review and meta-analysis. *International Journal of Nursing Studies*, *92*, 109–120. https://doi.org/10.1016/j.ijnurstu.2019.02.006

Lechner, A., Lahmann, N., Neumann, K., Blume-Peytavi, U., & Kottner, J. (2017). Dry skin and pressure ulcer risk: a multi-center cross-sectional prevalence study in German hospitals and nursing homes. *International Journal of Nursing Studies*, *73*, 63–69. https://doi.org/10.1016/j.ijnurstu.2017.05.011

Martins, M. D. d. S., Ribas, P. S. C., Sousa, J. R. A., Silva, N. A. P. d., Preto, L. S. R., & Correia, T. I. G. (2016). Facial pressure ulcers in inpatients undergoing non-invasive ventilation in intermediate care units. *Revista De Enfermagem Referência*, *4*(10), 103–111.

Mehta, C., Ali, M., Mehta, Y., George, J. V., & Singh, M. K. (2019). MDRPU – an uncommonly recognized common problem in ICU: a point prevalence study. *Journal of Tissue Viability*, *28*(1), 35–39. https://doi.org/10.1016/j.jtv.2018.12.002

Otero, D. P., Domínguez, D. V., Fernández, L. H., Magariño, A. S., González, V. J., Klepzing, J. V. G., & Montesinos, J. V. B. (2017). Preventing facial pressure ulcers in patients under non-invasive mechanical ventilation: a randomised control trial. *Journal of Wound Care*, *26*(3), 128–136. https://doi.org/10.12968/jowc.2017.26.3.128

Padula, W. V., & Delarmente, B. A. (2019). The national cost of hospital acquired pressure injuries in the United States. *International Wound Journal*, *16*(3), 634–640. https://doi.org/10.1111/iwj.13071

Raurell-Torredà, M., Romero-Collado, A., Rodríguez-Palma, M., Farrés-Tarafa, M., Martí, J. D., Hurtado-Pardos, B., Florencio, L. P-S., Saez-Paredes, P., & Esquinas, A. M. (2017). Prevention and treatment of skin lesions associated with non-invasive mechanical ventilation. Recommendations of experts. *Enfermería Intensiva*, *28*(1), 31–41. https://doi.org/10.1016/j.enfi.2016.12.001

Schallom, M., Cracchiolo, L., Falker, A., Foster, J., Hager, J., Morehouse, T., Watts, P., Weems, L., & Kollef, M. (2015). Pressure ulcer incidence in patients wearing nasal-oral versus full-face noninvasive ventilation masks. *American Journal of Critical Care*, *24*(4), 349–356. https://doi.org/10.4037/ajcc2015386

Siotos, C., Bonett, A. M., Damoulakis, G., Becerra, A. Z., Kokosis, G., Hood, K., Dorafshar, A. H., & Shenaq, D. S. (2022). Burden of pressure injuries: findings from the global burden of disease study. *Eplasty*, *22*, e19.

Strickland, S. L. (2019). The patient experience during noninvasive respiratory support. *Respiratory Care*, *64*(6), 689–700. https://doi.org/10.4187/respcare.06642

Tai, C. H., & Hsu, M. Y. (2016). Preventing facial pressure injuries in patients who use noninvasive positive pressure ventilators: the efficiency of dressings. *The Journal of Nursing*, *63*(5), 86–94. https://doi.org/10.6224/JN.63.5.86

Tang, J., Zhang, S., Chen, Q., Li, W., & Yang, J. (2020). Risk factors for facial pressure sore of healthcare workers during the outbreak of Covid-19. *International Wound Journal*, *17*(6), 2028–2030. https://doi.org/10.1111/iwj.13434

Wei, Y., Pei, J., Yang, Q., Zhang, H., Cui, Y., Guo, J., Guo, X., Ma, Y., & Han, L. (2023). The prevalence and risk factors of facial pressure injuries related to adult non-invasive ventilation equipment: a systematic review and meta-analysis. *International Wound Journal*, *20*(3), 621–632. https://doi.org/10.1111/iwj.13903

Winck, J. C., & Gonçalves, M. R. (2011). The evolution of practice of noninvasive ventilation: epidemiologic outcomes and patient's preference. *Journal of Personalized Medicine*, *9*, 1–5. https://doi.org/10.1007/s12682-011-0075-9

Worsley, P. R. Prudden, G., Gower, G., & Bader, D. L. (2016). Investigating the effects of strap tension during non-invasive ventilation mask application: a combined biomechanical and biomarker approach. *Medical Devices: Evidence and Research*, *9*, 409–417. https://doi.org/10.2147/MDER.S121712

