



Skin Injuries and its Related Factors in the Neonatal Intensive Care Unit

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ABSTRACT

Background: Skin is the most important defense mechanism of the neonate's body. The admission to the Neonatal Intensive Care Unit (NICU) is a risk factor for neonatal skin injuries. Therefore, to prevent these complications, it is essential to identify the risk factors. The present study aimed to investigate the incidence of skin injuries and its related factors in neonates admitted to the NICU.

Methods: This cohort study was conducted in two NICUs in one perinatal hospital in Tehran, Iran, from January 2018 to June 2018. The sampling was performed using the census method. The data were collected through a demographic characteristics form, a risk factor assessment checklist, and the European Pressure Ulcer Advisory Panel (EPUAP) tool. The data were analyzed in SPSS software (version 19) through Fisher's exact test and chi-square test.

Results: Out of 368 neonates, 126 cases had skin injuries, and the others were healthy. The mean values of weight and age of the neonates with skin injuries were 796.68 ± 1606.82 g and 5.18 ± 30.82 days, which was significantly lower than those of the infants without skin injury ($P < 0.05$). The results of the risk factors analysis also showed that the second-grade injuries were the most frequent. Moreover, the drug leakage (14.2%, n=33) and nasal continuous positive airway pressure (12.06%, n=28) had the highest prevalence. The results of the effect of risk factors on the wound grade also showed that drug leakage, diaper rash, and surgical injuries had a significant effect on the wound grade.

Conclusion: The results showed that in addition to neonatal conditions, equipment, and neonatal care play a significant role in the incidence of skin injuries. Skin is the most important defense barrier of the neonate's body and it is vitally important to take care of it. Therefore, it is necessary to identify and prevent such injuries.

Keywords: Injury, Neonate, NICU, Related factors, Skin

Introduction

Newborns have specific physiological needs to adapt to the extrauterine environment and often require special care. Approximately, 9% of all births require neonatal intensive care (1, 2). Although admission to the Neonatal Intensive Care Unit (NICU) increases neonatal survival rate, it causes various injuries, including skin injuries. Hospitalized infants are at risk of various skin injuries due to immature skin, inadequate perfusion, reduced mobility, neuromuscular changes, fluid imbalance, dehydration, and inadequate nutrition (3). Many invasive diagnostic and care procedures in the NICU somewhat

involve the skin. Infant's skin may be scratched, abraded, punctured, or underwent chemical and thermal burn (4). Therefore, NICU admission is a risk factor for skin injuries, and if it is not managed properly, it has been the underlying cause of morbidity in neonates (5). Various studies have reported the incidence of skin injuries between 3.70 and 43.1% and even more than 50% in preterm infants (6-9). The skin is the largest surface of the neonate's body and acts as a protective layer in many functions, such as protection, immunity, body temperature regulation, metabolism, and fluid balance (10). In

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addition to deformity, skin injuries can also reduce the function of the injured organ. Even in some cases, the infection can lead to septicemia, which in addition to the prolonged hospital stay, may increase financial costs and even neonatal death (6). On the other hand, repairing skin injuries is a painful process for the infant that may disrupt the developmental outcomes of neonatal conditions (7).

According to the reports by medical staff, especially physicians and nurses, neonatal skin injuries are one of the main causes of parental complaints (5). Therefore, it is essential to maintain the integrity of the skin as a protective barrier in the neonate. Moreover, it is of doubled importance to prevent skin injuries and adopt an appropriate care strategy (11).

Skin injuries mean damage to various skin layers ranging from the epidermis to the underlying layers, and even muscles, as well as tendons, which are most likely caused by equipment pressure or caring procedure (12). Skin injuries are caused by different factors. One of the most common skin injuries in the neonatal intensive care is the use of adhesives for fixing vein access devices or pulse oximeter probes and thermal sensors for fixing the endotracheal tube in neonates (5). In some studies, care equipment and neonatal conditions, including infant's weight and age, clinical status, and underlying diseases, were found to be effective in skin injuries (5, 7, 9). Other studies have pointed to the leakage of serum and drugs into the subcutaneous layer of skin as a causative agent of skin injuries (13). Nesses et al. also reported skin injuries due to inadequate change position, diaper rash, and unwanted cuts while using scissors or scalpel blades (11). Therefore, skin injuries are an important care challenge in the NICUs, and nurses can play a significant role in reducing these injuries by the identification and management of these factors (14).

Various studies found that nurses performed moderately in skincare in the NICUs (15). In a study aimed at auditing nursing skincare in the NICU, Salimi et al. found that nurses had no satisfying performance in neonatal skincare (16). Furthermore, Naeimi et al. reported a large gap between nursing extravasation standards care and the current condition in our hospitals (17).

Therefore, skincare is regarded as the most important defense mechanism in neonates. The identification of skin injury risk factors can be a guide to prevent complications and provide high-quality neonatal care. Therefore, the present study

aimed to determine risk factors for skin injuries in neonates admitted to the NICUs.

Methods

This cohort study was conducted to determine the incidence of skin injuries and its related factors in neonates admitted to the NICUs ($n=2$) of a perinatal hospital in Tehran, Iran. The sampling was performed using a census method after obtaining the code of ethics (1398.058) from January 2018 until June 2019. The inclusion criteria were only parental consent for infant participation in the study. On the other hand, the exclusion criteria were the parents' unwillingness and neonatal death. The research procedure and objectives were explained to the parents, and written informed consent was obtained from them. All neonates admitted during this time were included in the study. In total, 51 infants were excluded from the study due to death ($n=48$) and parental unwillingness ($n=3$) to continue participating in this study.

The data were collected using the European Pressure Ulcer Advisory Panel (EPUAP), a demographic characteristics form, and an observational checklist of risk factors. The EPUAP is a standard tool for skin assessment provided by the European Wound Management Association. Moreover, demographic characteristics form and the observational checklist of risk factors associated with skin damage were prepared based on the literature review by the research team members. The demographic characteristics form covers such information as neonate's age, gender, and gestational age.

Furthermore, an observational checklist of the risk factors associated with skin injuries seeks information about the length of stay and nutrition type of the neonate. The observational checklist consists of two parts, the first section of it measures the equipment-related factors, including endotracheal tube, nasal continuous positive airway pressure (NCPAP), monitoring probe, feeding tube, chest tube, and vascular access devices. The second part includes factors related to caring interventions, such as change position, diaper rash, surgical wound, drug leakage, phototherapy, and skin burn (Table 1). This 24-item checklist was initially designed based on textbooks, articles, protocols, and NICU skincare standards. The face validity of the checklist was evaluated regarding the appearance of the phrases, clarity, and simplicity of the expressions. It should be mentioned that the revisions were made to the final questionnaire. The content

Table 1. Demographic characteristics of the neonates hospitalized in the NICU

Demographic characteristics		Number	With skin injury	Without skin injury	P-value
Gender	Male	368	126	242	P>0.05
	Female	195	71	124	
Gestational Age		33.93±4.28	30.8254±5.18	36.7699±2.40	P<0.001*
Weight		2392.63±896.24	1606.8254±796.68	2804.3096±638.46	P<0.001*
Length of hospitalization		35.9±19.8	38.34±16.91	35.90±19.81	P<0.001*
Feeding	Total parenteral nutrition	102	57	45	P>0.1
	Gavag and total parenteral nutrition	153	51	102	
	Gavag and oral	113	18	95	

validity was confirmed using an expert panel, including NICU nurses (n=5), neonatal physicians (n=3), and nursing faculty members (n=4) in the pediatric department of the nursing school. The content validity index was calculated, and phrases with less than 80% validity were omitted. Finally, a 22-item checklist was obtained in this study. Moreover, the intra-class correlation coefficient (ICC) scores of the EPUAP tool and observational skin injury checklist were obtained at 0.88 and 0.91, respectively.

Before the study, the researcher selected two perfect clinical nurses. The nurses were then given explanations on how to assess and record injuries based on the checklist. The data collection team consisted of a researcher and three clinical nurses. The demographic characteristics of the neonates admitted to the NICUs were collected using a form. A numeric code was assigned to each neonate to keep data confidential. Afterward, neonatal skin assessment was performed and recorded by each research team member that was present at the shift.

Subsequently, the skin assessment was conducted every day by trained nurses until neonatal discharge, and any injury was recorded. To verify the data, the researcher randomly and blindly selected neonates twice a week and reassessed their skin. In the next stage, the documentations were collected by the researcher, and all information was recorded in SPSS software (version 22).

The data were analyzed in SPSS software (version 22). The incidence of skin injuries was calculated using the cumulative incidence formula (%)=PU/total number of infants in sample×100. This method has been used based on similar studies. Pearson, chi-square test, and Fischer's exact tests were utilized to investigate the correlations of skin injuries with demographic characteristics and related factors. It is worth mentioning that these tests were selected due to the type of tools. A p-value less than 0.05 was

considered statistically significant.

Ethical considerations

The study proposal was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran (IR.SBMU.PHARMACY.REC.1398.058). The research procedure and objectives were explained to the parents, and informed consent was obtained from them. They were also assured of the confidentiality of their data. Only the researcher had access to complete information.

Results

Out of 368 neonates, 195 (52.9%) cases were male. The mean gestational age, weight, and length of stay were 33.93 weeks, 2392.63 g, and 35.9 days, respectively. Regarding the nutritional status, intravenous, oral, and intestinal nutrition had the highest frequency. During the hospitalization in the NICUs, 126 neonates had skin injuries with one (n=53), two (n=40), and three (n=33) kinds of injuries. The mean values of weight (1606.8254±796.68) and gestational age (30.8254±5.18) of the neonate with skin injury were significantly lower than those of the healthy infants (P<0.05). There was also a significant difference between the two groups in terms of the length of stay in the NICUs. The neonates with skin injury had a significantly longer hospital stay in the NICUs (38.34±16.91), compared to the neonates without skin injuries.

The results revealed that the grade-2 skin damage had the highest frequency and was caused by drug leakage (n=33, 14.2%) and NCPAP (n=28, 12.06%) in descending order. The results of the effect of risk factors on the wound grade showed that skin surgical site, diaper rash injuries, and drug leakage had a significant effect on the wound grade.

Discussion

This study aimed to determine the incidence of

skin injuries and its related factors in neonates admitted to the NICUs. According to the results, 34.2% of the newborns in the NICU had skin injuries, and the majority of them suffered from second-grade skin injuries. Previous studies have reported that the incidence rates of these injuries in the NICUs were between 12.7% and 31.2% (5-8, 18). Moreover, NICUs are a potential risk factor for neonatal skin injuries (5). Infants are admitted to the NICUs for various reasons, such as prematurity. Therefore, physiological differences between full-term and preterm infants lead to some skin injury. In this regard, the results of the present study revealed that low fetal age, low birth weight, and longer hospitalization in NICUs were the risk factors for skin injuries. Numerous studies have confirmed these results (7, 9). The skin of the preterm infant is immature and fragile. The risk of percutaneous fluid linkage is greater in preterm infants, and they are vulnerable to thermal instability and hypothermia, dehydration, and electrolyte imbalance (10). Moreover, the capacity of the neonate's skin to withstand pressure depends on various factors, such as skin moisture, nutrition, motility, and tissue perfusion (12). Therefore, it is reasonable to observe more vulnerability to skin injuries in preterm neonates. Preterm neonates also require longer stay in the NICU and are more exposed to the routine diagnostic and therapeutic procedures. Therefore, skin injuries are more likely in them, which is consistent with the results of the present study.

Common procedures in the NICUs, including invasive procedures, equipment, and a variety of care interventions cause injury to neonates (5). The results of the present study also showed that grade-2 injuries were the most common skin injuries caused by vascular drug leakage. Consistent with these results, August et al. showed that out of 77 skin injuries, most cases ($n=24$) were related to vascular leakage (18). Naeimi et al. also reported that 73 out of 200 vascular leakage-related injuries in the NICU were grade-2 skin injuries (17).

Moreover, in a study conducted by Bealls, extravasation and drug leakage rates in neonates were estimated at 70-75% and 11-23%, respectively (19). In a similar vein, a study of 1000 peripheral venous catheters in hospitalized neonates showed that 35.4% of them were changed due to drug leakage (20). In neonates, arteries' walls are very delicate, and incorrect insertion of intravenous catheters can easily lead to the rupture of these delicate walls and cause fluid to penetrate the tissue space (21).

Prematurity and infusions of inflammatory drugs or vasoconstrictor drugs and fluid delivery via peripheral intravenous catheters are the most common causes of skin injuries in neonates (3, 9, 10). In this study, most of the infants were preterm, and the majority of them received intravenous feeding solutions. Therefore, it is expected to see a greater incidence of such skin injury (22). Inconsistent with the results of the above studies, the results of a recent study on 104 NICU neonates in Brazil showed that fluid leakage was the third most common cause of skin injuries with an incidence of 12.5%, and there were no reports of drug leakage (23). Although catheter insertion and injection of drugs and serum are common procedures in NICUs, deployment of perfect nursing staff can reduce these complications.

In an audit of extravasation care at three hospitals with NICU, Naeimi et al. showed a gap between nurses' performance and caring standards. They attributed this gap to the insufficient awareness of the nurses, as well as lack of facilities and equipment (17). It may, therefore, be possible to attribute such inconsistency to the difference in the caregiving environment in terms of human resources and facilities.

The equipment-related risk factor which is known as noninvasive ventilation (NIV) is the most common injury, which was reported in 20-60% of cases in different studies (3, 7, 9, 18). The NIV is fixed to the neonate's head and face in the form of a mask (24). A mask of an inappropriate size may become over-fixed and put pressure on the neonate's face and nose, and if the skincare is not carried out correctly, the risk of injury can be increased. On the other hand, since the NIV is a non-invasive ventilation strategy (10), it is anticipated that the infant with NIV will have difficulty with ventilation. Therefore, inadequate oxygenation and inappropriate perfusion can also increase the risk of skin injury (9). Other studies have not identified NIV as the first common risk factor of skin injury (23). Since NIV is a widely used ventilation method in preterm infants, this difference in findings could be due to different physiological conditions of the neonate, an underlying disease, and appropriate equipment, including different NIV sizes.

In addition to reporting the incidence of risk factors, the present study also investigated the effect of these factors on the wound grade. Among risk factors regarding the association of skin injury with equipment and care interventions in

Table 2. Risk factors for skin injury associated with equipment and care interventions in the NICU

Risk factors for skin injury	Frequency	Skin injury Grade1	Skin injury Grade2	Skin injury Grade3	P-Value
Equipment					
Vein Access	22 (9.4%)	9	8	5	0.673
Intratracheal tube	20 (8.6%)	7	10	3	0.346
Nasal continuous positive airway pressure	28 (12.06%)	8	17	3	0.029
Sensore	14 (6.03%)	3	8	3	0.527
Blindfold	7 (3.01)%	4	3	0	0.06
Chest tube	11(4.7%)	4	6	1	0.416
Feeding tube	14 (6.03%)	4	8	2	0.662
Care Interventions					
Surgery	11 (4.7%)	2	7	2	0.04
Position	22 (9.4%)	8	10	4	0.534
Drug leakage	33 (14.2%)	12	14	7	0.053
Burn	5 (2.1%)	3	1	1	0.149
Vein puncture	19 (8.1%)	5	10	4	0.019
Phototherapy	10 (4.3%)	6	4	0	0.51
Diaper rash	16 (6.8%)	11	5	0	0.03
Total	100%	86	111	35	

the NICU, the results showed a significant difference between the grade of skin wound grade and extravasation, surgical injuries, as well as diaper rash (Table 2). The most common types of injuries were also second- and first-grade skin injury in descending order.

The surgical injuries were mostly grade-2 and caused by ostomy. In this study, due to the inadequate stoma size, a dressing was placed on the ostomy site and fixed on the skin using adhesive bandages. The stool may leak to the surrounding skin under these conditions. Epidermal detachment is also likely to occur due to the removal of adhesive bandages. On the other hand, neonates with a stoma are at risk of nutrition disorders. The absence of proteins, calories, and fats lead to a potential injury and delayed recovery process (7, 18). Therefore, considering the stool PH and its higher damaging nature, the occurrence of second-grade skin injury seems reasonable. Diaper rash was another risk factor that mostly led to first-grade injury. This condition usually occurs in infants and causes discomfort and parental anxiety and concern. Since routine infant care is provided every 3 h by nurses or parents, any injuries are quickly identified and diagnosed. Therefore, it can justify the low grade of injuries. However, if skin injury is not being properly cared for, there is a possibility of infection and the development of skin damage.

Limitations

Since nursing care is one of the most effective factors for the incidence of skin injuries, it is important to investigate personnel-related factors, which was one of the limitations of the present

study. Considering the development of the NICUs, more personnel were recruited in this ward, and it was impossible to evaluate this variable due to differences in their knowledge and skills. Another limitation was the impossibility in determining the relationship between the wound grade and the type of injury. Since some injuries had a low prevalence rate, the results of the study are not generalizable, and further studies are recommended to be conducted with a larger sample size.

Conclusion

Overall, the results of the present study showed that equipment and interventional care play a significant role in the incidence of neonatal skin injuries in addition to neonatal conditions. Skin is the most important defense mechanism in the neonate's body, and it is vitally important to take care of it. Therefore, it is of utmost importance to prevent and manage skin injury considering the risk factors. Researchers suggest that educational courses must be provided to neonatal nurses about skin injury prevention with emphasis on related risk factors. Moreover, daily assessment of NICU-admitted infant's skin is very helpful to prevent an increase in the degree of neonatal skin injury.

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Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of the study.

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