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Risk Factors of Neonatal Medical Adhesive-Related Skin Injury and Management of High-Risk Nodes

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Abstract: *Objective:* To analyze the risk factors of neonatal medical adhesive-related skin injury and put forward targeted preventive measures, so as to provide reference for the care and prevention of neonatal medical adhesive-related skin injuries. *Methods:* Using the convenience sampling method, 262 neonates admitted to the neonatal intensive care unit (NICU) of a tertiary general hospital in Wenzhou from April 2021 to May 2022 were selected as the study subjects. The incidence of medical adhesive-related skin injuries in these neonates was retrospectively analyzed. *Results:* Among the 262 children, 43 cases had skin injuries, with an incidence rate of 16.4%. Single factor analysis showed that the occurrence of medical adhesive-related skin injury was related to gestational age, weight, electrocardiogram (ECG) monitoring, venous access, ambient temperature, and mechanical ventilation ($P < 0.05$). Multivariate logistic regression showed that gestational age, ECG monitoring, and ambient temperature were independent risk factors of medical adhesive-related skin injury (OR values were 0.700, 0.431, and 6.365, respectively). *Conclusion:* The high incidence of neonatal medical adhesive-related skin injury may be caused by one or more factors. Clinical measures should be taken, such as selecting the appropriate type of adhesive according to gestational age and using skin-protecting membrane, minimizing ECG monitoring, *etc*., to prevent the occurrence of neonatal medical adhesive-related skin injury.

Keywords: Newborn; Medical adhesive; Skin injury; Risk factor

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1. Introduction

Medical adhesive-related skin injury (MARSI) refers to skin abnormalities, such as persistent erythema lasting for more than 30 minutes, with or without blisters, erosion, or tearing, that occur after the removal of medical adhesives [1]. Newborns, especially premature infants, are at high risk of skin injury due to their thin skin and weak adherence between the epidermis and dermis. Currently, adhesive products are widely used in neonatal clinical care. Studies have shown that MARSI is the main cause of skin injury in neonatal intensive care units (NICUs), with a prevalence rate of approximately 8%–17% [2,3]. MARSI not only causes pain to the infants, but also prolongs hospitalization. Consequently, the prevention and reduction of MARSI in neonates, as clinical challenges, have become the focus of attention. The aim of this study was to examine the factors that contribute to MARSI in newborns and suggest specific measures for effective management in hope to provide some reference for the prevention and management of MARSI in neonatal care settings.

2. Materials and methods

2.1. General information

A total of 262 newborns admitted to our department from April 2021 to May 2022, including 150 male infants and 112 female infants, were included in this study.

Inclusion criteria: (i) currently or previously using medical adhesives; (ii) age ≤ 28 days; (iii) no skin injury on admission; (iv) good rapport between the healthcare team and the family and no unresolved medical disputes. The family members were informed and willing to participate voluntarily.

Exclusion criteria: congenital skin diseases, such as epidermolysis bullosa.

2.2. Methods

2.2.1. Survey and statistical methods

(i) Based on literature review [5-10], a standardized questionnaire (gender, gestational age, weight, length of hospital stay, skin edema, gastric tube placement, electrocardiogram [ECG] monitoring, blue light therapy, ambient temperature, type of adhesive, mechanical ventilation, and intravenous access) was developed. (ii) Using the retrospective case study method, two trained members of the research team reviewed the cases, recorded the data obtained from the standardized questionnaire, and entered the relevant data into a computer. Statistical analysis was conducted using SPSS. (iii) Depending on the occurrence of MARSI, the subjects were divided into two groups: an observation group and a control group. MARSI occurred in 43 cases, while the remaining 219 cases had no MARSI. Comparison of baseline data between the two groups showed no significant difference ($P > 0.05$). (iv) Univariate analysis was first performed on the observation group, followed by binary logistic regression analysis to determine the significant risk factors.

2.2.2. Diagnosis of MARSI

MARSI was diagnosed when the skin showed abnormalities, such as persistent erythema for at least 30 minutes after the removal of medical adhesives, with or without blisters, erosion, or tearing. It can be classified into four types: erythema, blisters, erosion, and tearing.

2.3. Statistical analysis

SPSS 21.0 was used for statistical analysis. Count data were analyzed using chi-square test, and measurement data were analyzed using t-test. Multivariate logistic regression analysis was performed to analyze the significant factors identified by univariate analysis. $P < 0.05$ indicates statistically significant difference.

3. Results

3.1. Incidence of MARSI

Among the 262 newborns, 43 had skin injuries, with a total of 84 occurrences, and the overall incidence rate was 16.4%. The types of injuries were mechanical injuries in 71 cases (84.52%), contact dermatitis in 9 cases (10.71%), skin infiltration in 3 cases (3.57%), and folliculitis in 1 case (1.19%). Among them, epidermal abrasions were the most common type of mechanical injury, accounting for 59.15% (42 occurrences), while tension injuries and skin laceration injuries accounted for 23.94% (17 occurrences) and 16.90% (12 occurrences), respectively. The types of adhesives that caused skin injuries were electrode pads in 14 cases (16.67%), transparent dressings in 34 cases (40.47%), elastic foam tapes in 20 cases (23.81%), 3M pressure-sensitive tapes in 11 cases (13.10%), ConvaTec patches in 5 cases (5.95%), and silicone tapes in 0 cases (0%).

3.2. Univariate analysis of MARSI in newborns

Table 1 shows the univariate analysis of MARSI in newborns. The results showed significant differences ($P < 0.05$) between the two groups of newborns in terms of gestational age, weight, intravenous access, ECG monitoring, ambient temperature, and mechanical ventilation.

Table 1. Univariate analysis of neonatal medical adhesive-related skin injury in NICU (n = 262)

Item	MARSI		Test statistics	*P*
	Yes (n = 43)	No (n = 219)		
Gender (n/%)			1.488[1]	0.222
Male	21 (48.84)	129 (58.90)		
Female	22 (51.16)	90 (41.10)		
Gestational age (w)	36.86 ± 2.848	35.30 ± 3.872	2.494[2]	0.013
Weight (g)	3,484.09 ± 494.631	3,033.96 ± 935.495	3.054[2]	0.002
Length of hospital stay	22 (10, 46)	34 (18,60)	1.946[3]	0.052
Ambient temperature	28 (27,29)	30 (29,32)	6.343[3]	＜0.01
Edema (n/%)			3.391[1]	0.066
Yes	16 (37.21)	52 (23.74)		
No	27 (62.79)	167 (76.26)		
Blue light therapy (n/%)			1.637[1]	0.201
Yes	13 (30.23)	89 (40.64)		
No	30 (69.77)	130 (59.36)		
Mechanical ventilation			10.982[4]	0.012
None	19 (44.19)	120 (54.79)		
Non-invasive ventilation	13 (30.23)	65 (29.68)		
Tracheal intubation	7 (16.28)	8 (3.65)		
High-flow nasal cannula	4 (9.30)	26 (11.88)		
Indwelling gastric tube			1.566[1]	0.211
Yes	13 (30.23)	47 (21.46)		
No	30 (69.77)	172 (78.54)		
Dry skin			1.194[1]	0.660
Yes	5 (11.63)	31 (14.16)		
No	38 (88.37)	188 (85.84)		
Intravenous access			14.786[1]	0.002
None	12 (27.91)	103 (47.03)		
Peripherally inserted central catheter	9 (20.93)	12 (5.48)		
Umbilical vein catheter	5 (11.63)	15 (6.85)		
Peripheral intravenous line	17 (39.53)	89 (40.64)		
Electrocardiogram monitoring			4.846[1]	0.028
Yes	14 (32.56)	39 (17.81)		
No	29 (67.44)	180 (82.19)		

Notes: [1]Chi-square value; [2]t-value; [3]Z-value; [4]Corrected chi-square test

3.3. Multivariate logistic regression analysis of MARSI

3.3.1. Variable assignment

Binary logistic regression analysis was performed, with the occurrence of neonatal medical adhesive-

related skin injury as the dependent variable and the suspected risk factors derived from univariate analysis as the independent variables. The values of the respective variables are shown in **Table 2**.

Table 2. Assignment of independent variables

Influencing factors	Variable	Assignment
MARSI	Y	No MARSI = 0, MARSI occurred = 1
Gestational age	X1	Input of original values
Body weight	X2	Input of original values
Ambient temperature	X3	Input of original values
Intravenous access	X4	None = 0, PICC = 1, Umbilical vein catheter = 2, Peripheral intravenous catheter = 3
ECG monitoring	X5	No = 0, Yes = 1
Mechanical ventilation	X6	None = 0, Non-invasive ventilation = 1, Endotracheal intubation = 2, High-flow nasal cannula = 3

3.3.2. Multivariate regression analysis

The results of multivariate regression analysis showed that gestational age, ambient temperature, and ECG monitoring were independent risk factors of MARSI in newborns, as shown in **Table 3**. The predictive accuracy of the three factors was 87% (> 60%), indicating that the analysis has high accuracy and practical value. This is shown in **Table 4**.

Table 3. Logistic regression analysis of neonatal MARSI

Variables	Regression coefficient	Standard error	Waldχ2 value	*P*-value	Odds ratio	95% confidence interval
Constant	0.422	6.939	0.004	0.951	1.525	
Gestational age	-0.356	0.123	8.382	0.004	0.700	0.550–0.891
Ambient temperature	0.359	0.145	6.106	0.013	1.431	1.077–1.902
Electrocardiogram monitoring	1.851	0.517	12.818	< 0.01	6.365	2.311–17.531

Table 4. Multivariable logistic regression analysis

Actual		Prediction		Percentage of correct predictions (%)
		MARSI		
		None	Occurred	
MARSI	None	209	10	95.4
	Occurred	24	19	44.2
Overall percentage				87.0

4. Discussion

4.1. Analysis of risk factors of MARSI in newborns

4.1.1. Effects of gestational age on MARSI in newborns

The results showed that gestational age is an independent but protective factor of MARSI in newborns (regression coefficient = -0.356, < 0). The larger the gestational age, the lower the risk of MARSI in newborns. The stratum corneum of fetuses matures at 30–32 weeks, and premature infants, especially those born before 30 weeks, have a thinner stratum corneum and weaker skin barrier, making them more

susceptible to skin injuries from tension or friction [3,11]. Therefore, it is necessary to be cautious when using adhesives in premature infants. Silicone tapes can be considered as an alternative to reduce skin injuries.

4.1.2. Effects of electrocardiogram monitoring on MARSI in newborns

The results showed that the probability of MARSI in newborns without ECG monitoring is only 15.7%, indicating a 6.37 times higher risk for newborns with ECG monitoring. Hydrogel is the type of adhesive type used in ECGs. It increases in adhesiveness over time and is prone to cause skin injuries in newborns. Therefore, we recommend to minimize ECG monitoring and use skin protective sprays to reduce skin injuries caused by hydrogel adhesives. In addition, regular replacement of adhesives could prevent prolonged adhesive contact with the skin in a specific area.

4.1.3. Effects of ambient temperature on MARSI in newborns

The results showed that ambient temperature is an independent factor of MARSI in newborns, where an increase in ambient temperature by 1°C could increase the incidence of MARSI by 1.43 times. This finding is consistent with the research of Wang *et al*. [12]. The adhesiveness of adhesive increases with temperature, possibly due to the softening of the adhesive and the filling of gaps between the adhesive and skin surface in high temperature. Additionally, higher ambient temperature leads to increased water loss and decreased skin elasticity, thereby increasing the risk of skin injuries. Therefore, it is recommended to keep newborns in a lower ambient temperature while maintaining their body temperature to reduce the effects of temperature on adhesives.

4.2. Characteristics and preventive measures of MARSI in neonates

4.2.1. Characteristics of MARSI in neonates

According to the findings of this study, the incidence of MARSI in neonates was 16.4%, which is consistent with previous local and foreign research [2, 11-12]. Mechanical injury is the primary cause of MARSI in neonates, accounting for 76.74% of cases. Epidermal stripping, in particular, is the most common form of injury, which may be attributed to the unique characteristics of neonatal skin. The connection between the epidermis and dermal layer primarily relies on fiber connections, and since neonates possess fewer fibers, the connection is not as tight. Hence, the binding strength between the adhesive and the epidermis is much greater than that between the epidermis and the dermis, making neonatal skin particularly vulnerable. In addition, neonates, especially premature infants, are known to have weak skin barrier, characterized by immature stratum corneum, greater exposure of the epidermis, increased loss of moisture, reduced elastic fibers, and heightened tendency toward edema. Poor techniques while removing adhesives are highly likely to cause epidermal stripping. Therefore, in clinical practice, it is crucial to apply high-risk node management based on the intrinsic skin characteristics of neonates and the factors that contribute to the occurrence of MARSI.

4.2.2. Management of high-risk nodes

4.2.2.1. Management of high-risk populations

Our research findings revealed that the smaller the gestational age, the higher the incidence of MARSI. Therefore, there is a need to strengthen the management of high-risk nodes for premature infants. For neonates with gestational age of less than 30 weeks, appropriate temperature and humidity-controlled warmers as well as transparent adhesive dressings should be used to reduce heat loss and water evaporation. Applying moisturizers can also reduce surface dryness of the skin and improve skin barrier. Prior to the use of adhesive products, skin protectants without alcohol are recommended for protection [13]. Applying a mixture of 0.9% sodium chloride injection and antibacterial aloe vera gel to the adhesive tape or a special

adhesive remover can reduce the incidence of MARSI in premature infants [14,15].

4.2.2.2. Management of product nodes

In this study, we found that the most common type of adhesive causing skin injury is transparent dressing, followed by elastic, soft, and wide tape. The adhesives used in these two types of products, as well as pressure-sensitive tape, are acrylic resins [16]. They have good initial adhesion, strong skin adhesion, and strong water resistance, rendering them suitable for fixing catheters and needles. However, their repeated use may cause skin injury. The results showed that the incidence of MARSI in neonates caused by pressure-sensitive tape was lower. This may be due to the fact that pressure-sensitive tape is commonly used for auxiliary fixation of blood oxygen saturation probes, skin temperature probes, and indwelling needles in clinical practice, all of which have a short duration of use. On the other hand, transparent dressings are commonly used to fix intravenous lines, while elastic, soft, and wide tapes are commonly used for tracheal intubation and to fix gastric tubes, all of which the duration of use is longer, thus increasing the adhesiveness over time. The results also showed that the use of silicone tape does not lead to MARSI. Silicone tape has mild and long-lasting adhesion, does not stick to hair, and can be reused. Its emphasis is in the gel itself, which can minimize skin damage [17]. However, it is less resistant to moisture than acrylic resins and rubber. Considering that it has lower adhesion and is expensive, its use is not recommended for the fixation of important lines [18]. The selection of appropriate medical adhesive products in clinical settings should be based on individual needs and the scenario for which the adhesive will be used.

4.2.2.3. Management of training nodes

Zhang *et al*. [15] emphasized the importance of providing training and education to healthcare workers on neonatal MARSI. Several studies have shown that the theoretical and operational knowledge of nurses regarding MARSI are at a relatively low level [19-21]. Most nurses have not received relevant training on skin care, are unaware of the importance of preventing MARSI, and have different methods for handling MARSI. Therefore, it is necessary to strengthen the theoretical and operational training of healthcare workers in neonatal departments, improve their ability to identify high-risk infants with MARSI, and standardize the methods for applying and removing adhesive tapes. For instance, before using adhesive products, appropriate skin protectants should be used; during application, the aseptic principle should be adhered to, with local skin kept clean and dry and the tape applied without tension and properly molded. When removing adhesive products, the tape should be removed at 0° or 180° in the direction of hair growth, using gentle movements, and if necessary, an adhesive remover [22].

5. Conclusion

In conclusion, the incidence of MARSI in newborns is high, and gestational age, ambient temperature, and ECG monitoring are independent factors that affect MARSI. Clinical training on MARSI-related knowledge and awareness in preventing MARSI in newborns should be strengthened for healthcare workers. Suitable medical adhesive tapes should be selected based on gestational age, and appropriate ambient temperature should be maintained. Learning the correct techniques of applying and removing adhesive tapes is also important, so as to reduce the incidence of MARSI in newborns.

In short, it is necessary to strengthen clinical measures to prevent and reduce the incidence of MARSI in newborns, so as to improve their quality of life and health status.

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Disclosure statement

The authors declare no conflict of interest.

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