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Application of Refined Nursing in the Prevention of Pressure Injuries in Pediatric Cardiothoracic Surgery

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Abstract: *Objective*: To explore the clinical value of refined nursing intervention in perioperative nursing for children undergoing cardiothoracic surgery, observe its preventive effect on pressure injuries in pediatric patients, and provide evidence-based references for optimizing specialized skin nursing protocols in pediatric cardiothoracic departments. *Methods*: A total of 86 children who underwent elective cardiothoracic surgery in the hospital from January 2022 to December 2025 were enrolled and randomly divided into the control group and the observation group using the random number table method, with 43 cases in each group. The control group received routine perioperative nursing for cardiothoracic surgery, while the observation group was administered whole-process refined nursing interventions on the basis of routine nursing, including preoperative risk stratification and assessment, intraoperative refined decompression protection for body position, multi-dimensional perioperative skin management, postoperative dynamic monitoring, and closed-loop management of nursing quality. The incidence of perioperative pressure injuries, the occurrence of abnormal skin conditions, and family nursing satisfaction were compared between the two groups. *Results*: The incidence of perioperative pressure injuries in the observation group was 2.33%, which was significantly lower than 16.28% in the control group (P<0.05). The total incidence of abnormal skin conditions, including skin flushing, moisture-induced injury, and friction damage, in the observation group was 6.98%, remarkably lower than 41.86% in the control group (P<0.001). The family nursing satisfaction rate of the observation group was 95.35%, higher than 76.74% in the control group, and all inter-group differences were statistically significant (P<0.05). *Conclusion*: Perioperative refined nursing implemented for children undergoing pediatric cardiothoracic surgery can accurately avoid high-risk factors for pressure injuries, effectively reduce the incidence of perioperative skin damage, maintain the integrity of children's skin, improve clinical nursing quality, and family medical satisfaction. Consistent with the development concept of pediatric precision nursing, this intervention has clinical promotion value.

Keywords: Refined nursing; Pediatric cardiothoracic surgery; Surgical nursing; Pressure injury; Skin protection

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1. Introduction

Pediatric cardiothoracic surgery is mainly applied to correct severe congenital pediatric diseases such as congenital heart disease, thoracic deformity, and congenital mediastinal and pulmonary lesions, serving as a core therapeutic approach to improve children's cardiopulmonary function and ensure their normal growth and development. Characterized by complex procedures and long operation duration, this type of surgery requires general anesthesia and cardiopulmonary bypass, which completely restricts patients' spontaneous activities and necessitates prolonged fixed surgical positioning, making pediatric patients a high-risk population for pressure injuries [1]. Compared with adults, children have immature physiological skin structures, featuring thin epidermis, high dermal water content, and underdeveloped skin barrier function. In addition, young children have uneven subcutaneous fat distribution, leading to poor compression resistance and shear resistance of local skin tissues. Prolonged local compression easily causes microcirculation disorders, further resulting in skin flushing, congestion, ulceration, and other pressure injuries [2]. Furthermore, multiple superimposed risk factors, including intraoperative hypothermia intervention, slowed peripheral circulation and intraoperative exudation induced by cardiopulmonary bypass, as well as long-term postoperative bed rest and insufficient nutrient intake caused by weak cardiopulmonary function, further elevate the risk of pressure injuries. Pressure injuries not only aggravate children's physical pain, induce crying and restlessness, and hinder the recovery of postoperative cardiopulmonary function, but may also trigger complications such as skin infection and unhealed wounds, prolong hospital stay, and increase the financial burden of families and the pressure of clinical nursing work [3]. Therefore, strengthening perioperative skin protection and precise prevention and control of pressure injuries in children undergoing cardiothoracic surgery is crucial for improving specialized nursing quality and ensuring smooth postoperative rehabilitation of children.

Current routine perioperative skin nursing in clinical practice is dominated by basic skin cleaning and passive postoperative condition observation, lacking precise preoperative risk assessment, intraoperative refined management, and continuous postoperative dynamic monitoring. It fails to adequately intervene in hidden high-risk factors such as moisture stimulation, positional shear force, and long-term low-pressure compression, resulting in insufficient foresight and relevance of nursing work, and cannot meet the skin protection needs of children with special skin characteristics [4]. As an evidence-based modern precision nursing model, refined nursing realizes accurate prevention and control of high-risk nursing risks through whole-process detailed management, stratified risk assessment, individualized intervention, and closed-loop quality control. Based on this, this study applied the refined nursing model to the whole perioperative period of children undergoing pediatric cardiothoracic surgery, constructed an integrated preoperative-intraoperative-postoperative skin protection system, and explored its preventive effect on pressure injuries in children, so as to provide a reference for the construction and clinical promotion of standardized skin nursing protocols for pediatric cardiothoracic specialty.

2. Materials and methods

2.1. General information

A total of 86 children who underwent elective cardiothoracic surgery in the hospital from January 2022 to December 2025 were selected as the research subjects and divided into the control group and the observation group by the random number table method, with 43 cases in each group. In the control group, there were 23

males and 20 females, aged 1–10 years, with an average age of (5.32±2.16) years; surgical types included 25 cases of congenital heart disease correction, 10 cases of thoracic deformity correction, and 8 cases of mediastinal and pulmonary surgery; the operation duration ranged from 1.5 to 4.5 h, with an average of (2.86±0.75) h. In the observation group, there were 24 males and 19 females, aged 1–11 years with an average age of (5.47±2.09) years; surgical types included 24 cases of congenital heart disease correction, 11 cases of thoracic deformity correction, and 8 cases of mediastinal and pulmonary surgery; the operation duration ranged from 1.6 to 4.6 h, with an average of (2.92±0.71) h. Baseline data including age, gender, surgical type, and operation duration were comparable between the two groups, with no statistically significant differences (P>0.05).

2.1.1. Inclusion criteria

(1) Children aged 1–11 years who met the indications for elective pediatric cardiothoracic surgery and underwent surgical treatment for the first time;
(2) Children with intact preoperative skin without damage, eczema, dermatitis, or a history of previous pressure injuries;
(3) Children with stable vital signs and no severe hepatorenal dysfunction or coagulation disorders;
(4) Families of the children were informed of the study content, volunteered to participate, and signed informed consent.

2.1.2. Exclusion criteria

(1) Children with preoperative skin infection, skin damage, or chronic skin diseases;
(2) Children with severe malnutrition, immune deficiency, or limb skeletal deformities;
(3) Children with intraoperative sudden massive hemorrhage, critical conditions requiring emergency rescue, and interrupted surgical procedures;
(4) Children with incomplete clinical data who were unable to cooperate with nursing interventions and follow-up.

2.2. Nursing methods

2.2.1. Control group

Routine perioperative nursing for pediatric cardiothoracic surgery was implemented. Preoperatively, routine skin cleaning, preoperative health education, and basic physical condition assessment were completed. Intraoperatively, standard surgical body position was assisted by physicians, with routine cotton surgical pads laid to maintain clean and dry surgical skin. Postoperatively, basic skin nursing was carried out, including regular turning over of children, keeping bed units clean and dry, routine skin condition observation, and timely symptomatic treatment for abnormal skin conditions such as flushing and damage. Meanwhile, basic dietary guidance and postoperative rehabilitation nursing were provided [5].

2.2.2. Observation group

On the basis of routine nursing, whole-process refined perioperative nursing interventions were implemented. Combined with the physiological skin characteristics of children and high-risk factors of cardiothoracic surgery, a closed-loop nursing system of preoperative risk stratification, intraoperative precise protection, postoperative dynamic monitoring, and whole-process quality control improvement was

constructed, with specific intervention measures as follows.

Preoperative refined risk assessment and pre-intervention. One day before surgery, the pediatric-specific Braden Q pressure injury risk assessment scale was used for special assessment of children. Multiple indicators, including children's age, weight, skin elasticity, nutritional status, limb mobility, estimated operation duration, intraoperative cardiopulmonary bypass, and hypothermia intervention, were comprehensively evaluated to accurately stratify low, medium, and high risk levels, establish individualized nursing files, and formulate targeted protection protocols. Special emphasis and enhanced targeted protection were placed on high-risk children with young age, low body weight, and estimated operation duration longer than 2 hours. Preoperative full-body skin cleaning was performed thoroughly, focusing on skin folds such as neck, armpits, lumbosacral region, and heels to remove sweat, stains, and residual sundries and avoid local compression and stimulation by foreign matter. Meanwhile, clinical nutritionists collaborated to evaluate children's nutritional status. For children with mild malnutrition and poor skin elasticity, families were guided to supplement high-quality protein and vitamins preoperatively to improve the tolerance of skin tissues. Special health education was conducted for families to elaborate on high-risk factors, key protection points, and cooperation matters of pressure injuries in pediatric cardiothoracic surgery, so as to improve family nursing cooperation.

Intraoperative refined body position management and decompression protection. Surgical body positions were individually and finely adjusted according to children's body shape, skeletal development, and specific surgical procedures to avoid long-term compression of bony prominences and shear force-induced skin damage. For children undergoing supine surgery, flexible medical decompression foam dressings were pasted on stressed parts, including the occiput, scapula, lumbosacral region, and heels, to replace traditional cotton cushions, and silica gel decompression positional pads were adopted to evenly disperse body pressure. For children undergoing congenital heart disease and thoracic deformity surgery, the shank elevation method was applied to suspend the heels completely, thoroughly eliminate compression on terminal parts, and reduce the risk of heel pressure injuries. Surgical bed sheets were fully flattened before surgery to avoid skin compression by folds and sundries; intraoperative negative pressure suction operations were standardized to prevent skin traction and friction caused by pipelines. In view of the slowed peripheral circulation induced by intraoperative cardiopulmonary bypass and hypothermia, limb warmth was maintained without affecting surgical operations to ensure normal skin blood perfusion. Intraoperative disinfectant, blood, and exudate were wiped away promptly to keep the skin dry throughout the operation and prevent damage to the skin barrier caused by moisture stimulation.

Postoperative refined dynamic skin monitoring and special nursing. Immediately after children returned to the ward postoperatively, comprehensive full-body skin assessment was performed, focusing on intraoperative key stressed parts. The skin color, integrity, swelling, and congestion were recorded in detail to improve the postoperative skin monitoring files. Special skin assessment was conducted every 1 hour within 6 hours after surgery and every 2 hours within 24 hours after surgery to accurately identify early occult skin damage and timely intervene in initial abnormal symptoms such as skin flushing and local congestion. Individualized turning plans were formulated based on children's postoperative cardiopulmonary function recovery. Turning movements were gentle without dragging or pulling limbs to minimize skin shear force and friction damage. Bed units were kept flat, dry, and debris-free throughout the nursing period, and damp clothes and bed linens were replaced in a timely manner. For children with postoperative bed rest and

ventilator-assisted ventilation, fixed pipelines and electrode patches were loosened regularly to avoid long-term local skin compression. In addition, individualized postoperative nutritional support was strengthened, and dietary protocols were formulated according to children's age, weight, and condition to enhance body resistance and skin tissue repair capacity.

Refined nursing quality control and continuous improvement. A special quality control group for pressure injuries in the department was established to organize regular professional training on pediatric skin protection and refined operations for nursing staff, so as to strengthen their ability to identify high-risk factors and master specialized nursing skills. The implementation of nursing measures, including skin risk assessment, decompression protection, and dynamic monitoring, was inspected daily. Skin abnormality data were summarized weekly to systematically analyze high-risk causes, and intervention procedures were optimized for weak links in nursing. A closed-loop nursing management model of risk assessment-precise intervention-dynamic monitoring-problem improvement was formed to continuously improve the quality of perioperative skin protection [1].

2.3. Observation indicators

(1) Incidence of pressure injuries: The occurrence of pressure injuries in children during the perioperative period (from preoperative to 72 hours postoperatively) was statistically analyzed. The injury grade was determined in accordance with the international pressure injury grading standard, and the total incidence was calculated.

(2) Occurrence of abnormal skin conditions: The number of cases and total incidence of various abnormal skin conditions, including skin flushing, moisture-induced injury, and friction damage, were compared between the two groups.

(3) Nursing satisfaction: A self-made family nursing satisfaction scale of the hospital was adopted for investigation, with a total score of 100 points. Scores of 90–100 points were defined as very satisfied, 70–89 points as satisfied, and <70 points as dissatisfied. Nursing satisfaction rate = (number of very satisfied cases + number of satisfied cases)/total number of cases ×100%.

2.4. Statistical methods

SPSS 26.0 statistical software was used for data analysis. Measurement data were expressed as mean ± standard deviation (Mean ± SD), and *t*-test was used for inter-group comparison; count data were expressed as cases (percentage) [n(%)], and x^2 test was used for inter-group comparison. The test level α was set as 0.05, and $P<0.05$ was considered statistically significant.

3. Results

3.1. Comparison of perioperative pressure injury incidence between the two groups

Only 1 case of stage I pressure injury occurred in the observation group, with an incidence of 2.33%; 7 cases of stage I–II pressure injuries occurred in the control group, with an incidence of 16.28%. The incidence of pressure injuries in the observation group was significantly lower than that in the control group, and the difference was statistically significant ($x^2=4.965$, $P=0.026$).

3.2. Comparison of abnormal skin conditions between the two groups

The incidence of each abnormal skin condition, including skin flushing, moisture-induced injury, and friction damage, in the observation group was significantly lower than that in the control group, and the total incidence of abnormal skin conditions was remarkably lower, with a highly statistically significant inter-group difference (P<0.001) (**Table 1**).

Table 1. Comparison of perioperative abnormal skin conditions between the two groups [n(%)]

Group	Number of cases	Skin flushing	Moisture-induced injury	Friction damage	Total abnormal incidence
Observation group	43	2(4.65)	1(2.33)	0(0.00)	3(6.98)
Control group	43	8(18.60)	6(13.95)	4(9.30)	18(41.86)
x^2 value	-	4.074	3.888	4.195	14.692
P value	-	0.044	0.048	0.041	<0.001

3.3. Comparison of family nursing satisfaction between the two groups

The family nursing satisfaction rate of the observation group was 95.35%, which was significantly higher than 76.74% in the control group, and the inter-group difference was statistically significant (P<0.05) (**Table 2**).

Table 2. Comparison of family nursing satisfaction between the two groups [n(%)]

Group	Number of cases	Very satisfied	Satisfied	Dissatisfied	Satisfaction rate
Observation group	43	32(74.42)	9(20.93)	2(4.65)	41(95.35)
Control group	43	21(48.84)	12(27.91)	10(23.26)	33(76.74)
x^2 value	-	-	-	-	6.198
P value	-	-	-	-	0.013

4. Discussion

Children undergoing cardiothoracic surgery belong to an extremely high-risk group for pressure injuries. The superposition of multiple risk factors, including the anatomical and physiological particularities of children's skin, prolonged intraoperative immobilization, intraoperative hypothermia and cardiopulmonary bypass intervention, and long-term postoperative bed rest, leads to a significantly higher risk of skin damage than children undergoing general surgery [6]. Pressure injuries not only cause physical pain, crying, and restlessness in children and affect postoperative cardiopulmonary function recovery and feeding status, but may also induce complications such as skin infection and unhealed wounds, prolong hospital stay, and increase family medical burden and clinical nursing pressure, serving as a vital adverse factor affecting the rehabilitation effect of pediatric cardiothoracic surgery [7]. Therefore, constructing a scientific and standardized refined perioperative skin protection system is the core measure to reduce the incidence of pressure injuries and improve the quality of pediatric cardiothoracic specialized nursing.

The conventional perioperative skin nursing model in clinical practice is extensive, dominated by passive postoperative observation and symptomatic treatment. It lacks precise preoperative risk screening, detailed intraoperative protection and continuous postoperative monitoring, and fails to effectively intervene in hidden high-risk factors such as positional shear force, long-term local low-pressure compression and moisture stimulation. The nursing model is deficient in foresight and pertinence, cannot meet the skin

protection needs of delicate children's skin, and has limited clinical preventive effects [8]. Adhering to the modern evidence-based nursing concept, the refined nursing model adopted in this study breaks the passivity and one-sidedness of traditional nursing, constructs an integrated whole-process closed-loop protection system covering the preoperative, intraoperative, and postoperative periods, and realizes accurate prevention and control of pressure injury risks [9].

Preoperative individualized risk stratification was performed via the dedicated Braden Q scale to accurately identify high-risk children, and targeted skin pre-intervention, nutritional intervention, and health education were carried out to avoid inducing factors of pressure injuries from the source and lay a foundation for perioperative skin protection. Intraoperatively, the extensive traditional body position placement method was abandoned, and individualized body position arrangement was conducted based on children's body shape and surgical procedures. Specialized decompression dressings and silica gel positional pads were applied to effectively disperse pressure on bony prominences. Meanwhile, intraoperative adverse stimuli such as moisture, friction, and low temperature were strictly controlled to minimize intraoperative skin damage [10]. Postoperatively, high-frequency dynamic skin monitoring was implemented to capture early occult skin damage in a timely manner. Combined with individualized turning nursing, pipeline skin protection, and nutritional support, the progression of skin damage was blocked to fully protect the integrity of children's skin. In addition, the special quality control and continuous improvement mechanism standardized nursing operation procedures, made up for the loopholes in routine nursing, and ensured the effective implementation of nursing measures.

The results of this study showed that the observation group had a significantly lower incidence of pressure injuries and total abnormal skin conditions, and remarkably higher family nursing satisfaction than the control group, confirming that refined nursing can effectively avoid high-risk factors for perioperative skin damage in pediatric cardiothoracic surgery and greatly reduce the incidence of pressure injuries and various abnormal skin conditions. The underlying reason is that refined nursing focuses on clinical nursing details, implements targeted interventions for exclusive high-risk factors of pediatric cardiothoracic surgery, and balances individuation and comprehensiveness, which effectively compensates for the shortcomings of routine nursing. It can not only accurately protect children's delicate skin and reduce physical damage, but also improve families' medical experience through detailed and high-quality whole-process nursing services, conforming to the development concept of modern pediatric precision nursing and humanistic nursing.

Meanwhile, this study has certain limitations. It is a single-center and small-sample clinical study with a follow-up period limited to 72 hours postoperatively, failing to observe the long-term skin recovery status of children. Future studies can carry out multi-center, large-sample controlled trials with prolonged follow-up periods, further optimize the refined nursing intervention process, and refine individualized protection protocols for children of different age groups and different surgical types, so as to provide more comprehensive evidence-based support for clinical standardized promotion.

5. Conclusion

The application of refined nursing intervention in the perioperative nursing of children undergoing pediatric cardiothoracic surgery can effectively identify and avoid high-risk factors for pressure injuries, significantly reduce the incidence of perioperative pressure injuries and various abnormal skin conditions, fully maintain the integrity of children's skin, and reduce the occurrence of postoperative complications. Meanwhile, it

can effectively optimize the quality of nursing services, improve family nursing satisfaction, and enhance doctor-patient relationships. With significant intervention effects and strong practicality, this nursing model conforms to the refinement development trend of specialized nursing and is worthy of clinical promotion and application in pediatric cardiothoracic departments.

Disclosure statement

The author declares no conflict of interest.

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