Application of HFMEA in PICC Nursing Management in Neonatal Surgery

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Abstract: Objective — To explore the application effect of healthcare failure mode and effect analysis (HFMEA) in PICC nursing management in neonatal surgery. Methods — Select 130 children who were treated in our department from January 2018 to February 2019. All children were given PICC puncture and catheterization, and the children were randomly divided into control group and observation group. The control group was given routine care, and the experimental group was given failure mode and effect analysis on the basis of the control group. Discover potential evaluation defects of failure modes, improper selection of blood vessels, imprecise selection of measurement methods, maintenance defects, etc., and implement improvement measures. The success rate of one-time catheterization, membrane replacement time, indwelling time, and incidence of PICC-related complications were compared between the two groups of children. Results — The success rate of one-time catheterization was higher and membrane replacement time was longer in the experimental group than those in the control group ($P<0.05$); the incidence of PICC-related complications in the experimental group was lower than that in the control group ($P<0.05$). Conclusion — Through teamwork, HFMEA has prospectively discovered and solved the problems in the use of PICC catheterization and achieved continuous improvement in the quality of care.

Keywords: healthcare failure mode and effect analysis, neonates, PICC nursing, nursing management

1. Introduction

In order to meet the needs of treatment and nutritional supply after neonatal surgery, the general medication time is longer. In order to safely use medication and reduce the pain caused by repeated venipuncture in children, PICC catheters have been widely used [1]. In clinic, because the neonatal PICC catheter is special, it is pre-trimmed, and the reserved length needs to be determined before puncture. Once the catheter is correctly positioned, the overall length of the catheter and the length of the external placement cannot be changed, but the predicted catheter insertion length and The occurrence of related complications caused by excessively long extracorporeal catheters [2]. Healthcare failure mode and effect analysis (HFMEA) is a forward-looking method for evaluating system processes [3], through root cause analysis and process improvement. Emphasize preventive behavior before the incident. Rather than remedy afterwards. This study aims to apply HFMEA to newborns with PICC catheters in our department, clarify the high-risk links and key steps of catheter insertion, and put forward feasible countermeasures to improve the safety of PICC retention. The report is as follows.

2. Materials and methods

2.1 General materials

We selected 130 children in our department who needed PICC puncture from January 2018 to February 2019. According to the random number table, the children were divided into two groups. In the control group, there were 65 cases, 37 males and 28 females, aged 5.82±1.52 days, and admission weight 2.02±0.53kg. There were 65 cases in the experimental group, including 32 males and 33 females, aged 5.22±1.33 days and admission weight 2.13±0.38kg. The comparison of gender and age between the two groups of children was $P>0.05$, and there was no statistically significant difference.

Inclusion criteria: newborns under 28 days of age; in line with PICC catheterization indications; family members signed the PICC catheterization informed consent. Exclusion criteria: combined with other infectious diseases except neonatal surgical diseases; catheter indwelling time is less than 5 days.

2.2 Methods

2.2.1 Establish HFMEA team

Criteria for selection of team members: bachelor degree or above; professional title of nurse or above; qualification certificate of intravenous infusion specialist nurse for more than 3 years.

2.2.2 Determine the flow chart

Using HFMEA [4], the project team discussed together to determine the flow chart of the catheterization process. Conduct risk assessments on key links in the PICC process and discuss improvements.

2.2.3 Calculate the risk priority number (RPN)

Calculate the RPN of each failure mode. The higher the RPN value, the higher the potential safety hazard [5], which is the part that needs to be processed further. Then the processing sequence is arranged according to the RPN value of each failure mode. For those whose RPN values are less than 125 points, you can put them in the end.

2.2.4 Potential failure modes

After evaluation and calculation, the potential failure modes of PICC risk management in our hospital are the following aspects: assessment defects, improper selection of blood vessels, inaccurate measurement methods, difficulty in delivery due to improper positioning or severe crying of the child during the catheterization process, difficulty in management, inaccurate X-ray reading, and maintenance defects. See Table 1.

Table 1. Failure mode analysis of risk problems during neonatal PICC catheterization

Failure modes	Potential causes	Results	O	D	S	RPN
Assessment of defects	Incomplete assessment	Catheter heterotopia	8	6	7	336
Improper choice of blood vessels	Inadequate understanding of vascular anatomy	Unsuccessful catheterization	8	7	8	398
Inaccurate measurement	Improper selection of measurement method	Exposed catheter is too long	8	6	8	384
Difficulty in delivery	Incorrect posture, unskilled operation, crying	Catheter heterotopia	4	4	6	96
X-ray reading is not accurate	There are differences between nurses and radiology departments	Catheter heterotopia	4	5	6	120
Maintenance defect	Infusion pump alarm processing is not timely, and the fixing method is not standardized	Catheter blockage, catheter displacement	6	6	7	252

2.2.5 Determine the focus of improvement

The improvement focus is determined according to the RPN value. The higher the RPN score, the greater the risk of failure. Among the six failure modes in this study, the RPN values of assessment defects, improper vessel selection, inaccurate measurement, and maintenance defects are all greater than 140 points, so these four failure modes are the focus of improvement.

2.2.6 Key improvement measures

(1) Perfect evaluation. In addition to assessing the child's condition, skin condition at the puncture site, coagulation function, etc. before the puncture, a comprehensive evaluation of the child's imaging data is very important for the selection of the puncture site. If it can be found that the anatomical structure of the heart and blood vessels of the child is abnormal. PLSVC[6], dextrocardia, single atrium, etc. provide important reference for the selection of puncture site and the measurement of body surface length, catheter orientation after puncture, and catheter tip positioning.

(2) Selection of appropriate blood vessels. All children in our department suffer from surgical diseases, and surgical treatment is the main treatment. Therefore, the surgical site should be referred to when choosing blood vessels to facilitate medical operations. ① Children with mechanical ventilation have limited body position. Rotating the head and extending the neck may cause the endotracheal tube to be displaced and ectopic[7], so children with mechanical ventilation do not have a tube through the external jugular vein. ② Children with congenital esophageal atresia and congenital diaphragmatic hernia underwent thoracoscopic surgery without catheterization through axillary vein. ③ Anorectal disease, intestinal stoma surgery without catheterization through femoral vein. ④ Generally, the expensive veins and superficial temporal veins are selected for catheterization, but the upper extremity catheterization requires high body position. If the child is in critical condition and urgently needs central venous access for fluid infusion, the femoral vein catheterization can be directly selected[8].

(3) Accurate measurement before placement. According to the PICC catheterization guidelines, "the tip of the catheter should be inserted to the lower 1/3 of the superior vena cava for the best position[9,10]." The length of the catheter is generally estimated by in vitro measurements, and the position of the catheter tip is checked by X-ray radiation. The length of the superior vena cava in neonates is about 2 cm, so the catheter length should be measured accurately. Use the one-

letter method [11], that is, take the distance from the pre-puncture point along the vein to the right sternoclavicular joint as the base length. If the body weight is less than 2500g, no additional length is added for preterm infants, and 1cm is added for term infants with a body weight of ≥2500g .

(4) Standardize catheter maintenance. ① Set the infusion pump parameters correctly, and check the blockage of the infusion pump in time, especially when the infusion rate is slow, find the precursor of the catheter blockage in time and make effective treatment. ② Choose an appropriate size transparent dressing to paste. Newborns generally use a 6*7 cm transparent dressing[12]. The specification requires that the puncture point be the center when pasting. Therefore, when the exposed catheter length is greater than 3 cm, 10*10 cm size film for fixing.

2.3 Observation indicators

Observe the operation time, indwelling days, and the incidence of complications during catheter indwelling in the two groups.

2.4 Statistical methods

This study uses SPSS 20.0 statistical software to complete data analysis.

3. Results

The success rate, membrane replacement time and indwelling time of the two groups of children are shown in Table 2. The success rate of one-time catheterization and membrane replacement time in the experimental group were higher than those in the control group, P <0.05.

Table 2. One-time catheterization success rate, membrane replacement time, and retention time of the two groups of children

	Number of cases	The success rate of one-time catheterization (%)	Membrane replacement time (min)	Indwelling time (d)
Control group	65	72.2%	15.18±2.22	12.50±2.70
Experimental group	65	93.4%	11.26±3.84	13.12±2.62
t/x^2		32.336	13.071	6.253
P		0.001	0.036	0.061

The complications (phlebitis, catheter displacement, catheter blockage, catheter-related infection) during catheter indwelling in the two groups are shown in Table 3. In comparison of phlebitis, catheter displacement, and catheter blockage between the two groups, the P value was less than 0.05, and the difference was statistically significant.

Table 3. Analysis of complications during catheter indwelling in the two groups

	Phlebitis	Catheter displacement	Catheter blockage	Catheter-related infection
65 cases in the control group	9	8	10	4
65 cases in experimental group	1	1	3	3
X^2	12.521	9.423	4.701	4.213
P	0.001	0.002	0.030	0.084

4. Discussion

4.1 Through analyzing the failure mode of the PICC catheterization process in the newborn, formulate risk management measures in advance to ensure safety during PICC catheterization

Strengthen the evaluation of the imaging data of the children before catheterization. For example, prenatal ultrasound can accurately diagnose PLsVC, add cardiac ultrasound and/or chest X-ray examination before PICC puncture, and find that the anatomical structure of the heart and blood vessels of the child is abnormal. However, if the situation is urgent when the catheter is placed and the congenital malformation cannot be clearly determined through the examination, it is recommended to choose the right upper limb, right head and neck or both lower limb veins for catheter placement as much as possible [12]. Neonatal superior vena cava is shorter, so the accuracy of PICC length is higher. Small errors may lead to changes in the head position. Accurate measurement should be performed before operation. The newborn are not suitable for traditional horizontal "L" measurement method. Most of the catheters by this measurement method is longer than the actual insertion length, which leads to too deep into the right atrium of the child, and even causes arrhythmia.

The characteristic of the PICC catheter in the newborn is that the front end is cut. If you wait for the X-ray positioning after the puncture, there is a lag in uploading pictures and inspection reports. You can only adjust the tube end position after the X-ray inspection report results come out [13]. Due to time constraints, you can only adjust the external catheter. However, the length of the external catheter cannot be trimmed, resulting in the exposed catheter being too long. The application of HFMEA to the management of neonatal PICC catheterization has a definite effect, which improves the success rate of puncture and shortens the catheterization time. Ensuring the accuracy of the catheter position is a prerequisite for improving the treatment effect. During the maintenance period of the catheter, the neonate uses a 1.9Fr catheter without a valve, and improper maintenance can easily block the tube. The infusion rate is too slow or suddenly interrupted, the crying of the child causes blood reflux and blood coagulation, etc., which are extremely related to the blockage of the catheter. Try to maintain the continuity of the infusion, use the infusion pump to eliminate the alarm factor in time. Comfort the child during the infusion and avoid violent crying.

Correctly choose the type of sterile transparent dressing for infusion. The 6*7 cm dressing is suitable for when the exposed scale of the catheter is "0", the catheter should be placed in a "C" or "L" shape, and the exposed scale of the catheter can be "S" when the scale is ≥2cm Placed and fixed [14]. Due to individual differences, after X-ray positioning adjustment, even if the catheter is placed in an "S" shape when the exposed scale is ≥3cm, a 10*10 cm transparent dressing should be selected to ensure that the fixed catheter disc should be fixed in the center of the membrane. If there is any leakage, blood oozing, loosening, or contamination at the puncture point, replace it in time. This study showed that the use of FMEA in the risk management of neonatal PICC catheterization can reduce the incidence of catheter-related complications ($P < 0.05$).

4.2 Pay attention to the continuous quality improvement and improve the clinical quality by continuously discovering problems, formulating countermeasures and solving them

HFMEA is a forward-looking method of risk identification and management[15]. Risk assessment of the severity and frequency of failure modes is the main purpose of its work. Through the quantitative indicator RPN, the failure mode risk is evaluated and ranked, and the highest risk is selected. The failure mode with a high RPN value means that the weak links in the nursing process are at great risk. We will develop targeted solutions [16], focus on prevention, and take corresponding care measures to eliminate risk factors in the bud or reduce them to the scope of acceptance. Carry out targeted improvement measures to make the PICC catheterization and maintenance process more standardized to ensure the improvement of nursing quality.

5. Conclusion

The HFMEA is a comprehensive management program that solves problems systematically and prospectively through teamwork. The HFMEA process is simple; the analysis results are quantified; the operation is simple and feasible; the continuous improvement of nursing quality is realized.

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