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Effect of Intracavitary ECG and P-wave Ratio on Neonatal PICC Localization

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Abstract: ***Objective:*** *To investigate the relationship between the P-wave size of neonatal PICC intracavitary electrocardiogram (ECG)tip and the position of PICC catheter tipin superior vena cava and its clinical effect.* ***Methods:*** *A total of 184 patients with PIC-C catheterization were enrolled in the study. They were randomly divided into observation group and control group according to the random number table method, 92 cases in each group. The control group took the regular body surface and the chest X-ray positioning after operation, while the observation group was located by intracavitary EC-G P-wave ratio and chest X-ray. The disposable catheter success rate and time of catheterization were compared between the two groups, and the position of catheter tip corresponding to different Pwaves was analyzed.* ***Results:*** *The PICC disposable catheter success rate of the newborns in the observation group was 95. 65(88/92), which was significantly higher than that of the control group (81.52%, 75/92) (P<0.01). The catheterization time and the puncture sitebleeding volume in the observation group were significantly lower than the control group(P<0.01). In the observation group, the tip of the catheter of 1/2 -2/3 R wave was mainly recommended by the guideline, the 1/3-1/2 R wave was mainly 2/3 of the superior vena cava, and the 1/2~2/3 R wave was mainly recommended by the guideline or right atrium, the difference was statistically significant (P<0.05).* ***Conclusions:*** *The P-wave ratio of intracavitary ECG is helpful to locate the tip of neonatal PICC.*

Keywords: Newborn, PICC catheterization, Electrocardiogram localization, P-wave.

1. Introduction

Peripherally inserted central catheters (PICC) represent a technique involving catheter insertion through peripheral veins, with the catheter tip positioned in the lower third of the superior vena cava. Due to advantages such as reducing pain stimulation ca-used by repeated venipuncture in neonates and extended indwelling time, PICC has been increasingly adopted in clinical practice [1]. It also serves as a vital lifeline for critic-ally ill newborns, particularly extremely low birth weight infants. The most common method for determining PICC tip position remains radiography. The 2021 edition of the Infusion Nurses Society (INS) [2] practice guidelines indicates that intracavitary electrocardiogram (ECG) technology can also assist in locating PICC catheter tips. This study investigated the effectiveness of upper limb PICC tip positioning in 184 neonates, focusing on the application value of intracavitary ECG P-wave analysis. The findings are presented as follows.

2. Data and Methods

2.1 General Information

A total of 184 neonates with upper limb PICC catheterization admitted to the NI-CU of our hospital from January 2020 to January 2022 were selected as the study subjects, and they were divided into observation group and control group, with 92 cases in each group. The control group was subjected to conventional body surface measurement and postoperative chest X-ray positioning, while the observation group was subjected to luminal electrocardiogram P-wave ratio and chest X-ray positioning. Inclusion criteria: (1) The infusiontime was > 1 week, and all of them met the indications for PICC catheterization; (2) There is no ulceration or scar on the skin at the puncture site; (3) No arrhythmia, heartrate100~160 beats/min; (4) Informed consent of the guardian to PICC catheterization. Exclusion Criteria: (1) Contraindications to PICC catheterization; (2) Diseases that affect the appearance or morphology of P waves, such as atrial fibrillation, atrial flutter, arrhythmia, electrocardiogram disorder, congenital heart disease, etc. This study was approved by the hospital ethics committee. There were no significant differences in gender, gestational age, body weight, puncture age, and venous puncture between the two groups (P>0.05) (Table 1), which were comparable.

Table 1: Comparison of neonatal general data between the two groups (n=184, Mean ± SD)

	Experimental group(n=92)	Control gr oup(n=92)	Test	*P*
Gendern (%)				
Female	45(48.91)	43(46.74)	χ^2=0.09	>0.05
Male	47(51.09)	49(53.26)		
Gestational age (weeks), Mean ± SD	30.71±2.56	30.82±2.14	t=0.32	>0.05
Birthweight (g), Mean ± SD	1509.42±486.85	1476.50±545.41	t=0.43	>0.05
Catheterization age/d	3.19±0.50	3.25±0.40	t=0.90	>0.05
Puncture site				
median elbow vein	38	39		
basilica vein	33	35	χ^2=0.85	>0.05
cephalic vein	1	2		
axillary vein	20	16		

2.2 Method

The control group adopts routine surface measurements and chest X-rays to locate the tip position of the catheter. The child is in a supine position, the upper limbs are abducted, forming a 90° angle with the trunk, and then the pre-puncture blood vessel is selected, and the predetermined insertion depth is determined according to the surface measurement. Starting from the puncture point, measure along the venous direction to the inneredge of the right sternal clavicular joint. For a body weight of <1.5kg, re-duce the measurement length by 0.5cm; for a body weight of 1.5-1.9kg, the measurement length remains unchanged; for a body weight >1.9kg, increase

the measurement length by 0.5cm. Operate strictly according to the PICC catheter placement process, standards, and aseptic principles. After the catheter is placed, perform chest X-ray localization. If the tip position of the catheter is abnormal, adjust it immediately, and then perform X-raylocalization reexamination. After confirmation, securely fix the catheter.

The observation group used an electrocardiogram monitor (Comen C100) on the basis of the control group. The child was in a supine position, with 3 electrode patches respectively placed on the lower margin of the left rib, near the right clavicle by the right shoulder, and near the left clavicle by the left shoulder. The lead wires were connected, the waveform was adjusted to the I lead electrocardiogram waveform, and the surface ECG was observed and saved. An aseptic converter was opened and connected to the H clip for standby. According to the routine operation of catheter placement, 10 mL of 0.9% sodium chloride solution was drawn before catheter placement, connected to a scalp needle and heparin cap, and the air was excluded to connect to the PICC tip. When the catheter was succesfully inserted to the predetermined length, the aseptic converter clip was connected to the scalp needle at the PICC tip, and 0.9% sodium chloride solution was slowly injected while closely observing the P wave changes. When the tip of the catheter entered the peripheral vein, there was no significant change in the P wave; when entering the superior venacava, the P wave gradually increased with the advancement of the catheter tip; when reaching the junction of the superior vena cava and the right atrium, it reached its peak, some exceeding the R wave; continuing into the right atrium, the amplitude of the P wave decrease-d, even showing a negative P wave. When a specific sharp P wave is observed and reaches the maximum amplitude, the catheter is retracted about 1.0 cm, the height of the P wave decreases, and it is properly fixed for chest X-ray positioning after surgery. If no P wave changes are observed during catheter placement, the position of the catheter needs to be adjusted. If no P wave changes are observed after several adjustments, the catheter is adjusted under the guidance of a bedside X-ray film.

2.3 Observation Indicators

The one-time placement of PICC catheterization in the two groups of neonates was recorded [3] (i.e., the catheter tip was located in the middle and lower 1/3 of the superior vena cava or the junction between the superior vena cava and the right atrium after catheterization, and the catheter tip was 1.0cm away from the heart in preterm infants and 2.0cm in full-term infants), and the time taken for PICC catheterization (from puncture disinfection to catheter delivery in place) and the amount of blood loss at the puncture site were recorded.

24 Statistical Methods

Employing t-test and chi-square test.

3. Results

3.1 Comparison of PICC Catheterization Related Indexes between the Two Groups

The one-time rate of PICC catheterization in the observation group was significantly higher than that in the control group (P<0.01), and the time of catheterization and the amount of blood loss at the puncture point in the observation group were significantly lower than those in the control group (P<0.01) (Table 2)

Table 2: Comparison of PICC catheterization-related indicators in neonates between the two groups

	Experimental group(n=92)	Control group(n=92)	Test	*P*
One-time tube placement	88(95.65)	75(81.52)	χ^2=9.08	<0.01
Insertion time / min (Mean ± SD)	15.50±3.11	21.08±2.97	*t*=12.45	<0.01
Puncture point Bleeding volume/mL (Mean ± SD)	1.06±0.25	1.83±0.30	*t*=18.92	<0.01

3.2 Comparison of Catheter Tip Positions in Different ECGI Lead P Wave States

In the observation group, the catheter tip of the 1/2~2/3R wave mainly reached the recommended position of the guideline (95.08%), the catheter tip of the 1/3~1/2R wave mainly reached the upper 2/3 of the superior vena cava (91.67%), and the catheter tip reached the recommended position of the guideline (73.68%) or the right atrium (26.32%) when the 2/3~4/5R wave was 2/3~4/5R, and the difference in the arrival position of the three bands was statistically significant (P<0.01) (Table 3).

Table 3: Catheter tip attainment position in different P-wave states of neonates in the observation group Compare [n(%)]

P-wave	*n*	Recommended location	2/3 of the superior vena cava	Right atrium	Others	Test	*P*
1/2~2/3R	61	58(95.08)	2(3.28)	1(1.64)	0(0)		
1/3~1/2R	12	1(8.33)	11(91.67)	0(0)	0(0)	χ^2=82.86	<0.01
2/3~4/5R	19	14(73.68)	0(0)	5(26.32)	0(0)		

4. Discussion

PICC catheterization is widely used in the treatment of neonatal critical care, and has the advantages of convenient operation, high safety and long indwelling time. However, for neonates with young age, poor vascular conditions, and large anatomical individual differences, PICC catheterization is prone to catheter tip dislocation and displacement [4]. At present, X-ray positioning is the “gold standard” for PICC catheter positioning, and the position and direction of the catheter tip can be clearly observed through X-ray positioning [5-6]. However, there is a certain lag in its positioning, and it is often necessary to readjust the position of the tubing or even reposition the catheter, which increases the consumption of medical resources, radiation exposure and the risk of infection. In order to avoid such conditions and reduce the occurrence of related complications, it is important to perform the puncture while dynamically monitoring the position of the catheter tip. The principle of action is to use 0.9% sodium chloride

solution water column or guidewire as the intraluminal electrode, and as the intraluminal electrode enters the superior vena cava to obtain the P wave morphological change on lead I to determine the position of the catheter tip. In PICC catheterization, the intraluminal electrode changes in P wave morphology as the catheter position moves deep [7]. When the catheter tip enters the peripheral vein, the P wave changes insignificantly; When the catheter tip enters the superior vena cava, the amplitude of the P wave gradually increases due to the proximity of the electrode probe to the sinus node. When the tip of the catheter is placed at the junction of the superior vena cava and the right atrium, the amplitude of the P wave reaches its peak; When the catheter tip enters the right atrium, the electrical activity of the sinus node shifts from a near-field potential to a far-field potential, exhibiting a negative P wave or a decrease in P wave amplitude [8-9]. Therefore, if a human PICC catheter is inserted through an upper extremity vein, the position of the catheter tip can be judged according to the change of P wave morphology.

The results of this study showed that the one-time placement rate of PICC catheter with luminal electrometry catheter tip positioning was 95.65%, which was significantly higher than that of the control group (81.52%).This is consistent with the results of Wang et al [10], that is, luminal electrocardiogram positioning can effectively locate the tipposition of the neonatal PICC catheter, which is higher than the conventional extracorporeal measurement plus chest X-ray positioning at one time. Studies [11] have shown that when the amplitude of the P wave is at 50%~70% of the height of the QRS wave, the catheter tip placement rate can reach 100% when the tip of the PICC lumen electrocardiogram catheter is positioned. At the same time, the time of catheterization and the amount of blood loss in the observation group were significantly lower than those in the control group. The possible reason is that ECG monitoring and positioning can achieve real-time positioning according to the P wave change during the operation, quickly determine the position of the catheter tip, and reduce the damage to the vascular endotheliium caused by mechanical friction caused by repeated catheter feeding and withdrawal, thereby reducing the amount of bleeding and shortening the operation time. In addition, due to the increased rate of catheter tip in place at one time, the number of repeat X-rays is reduced, which can reduce the probability of radiation exposure and infection in newborns, and reduce the discomfort of children [12]. Compared with traditional body surface measurement and chest X-ray positioning, ECG P-wave positioning is convenient, fast, and highly accurate, which is helpful to adjust the position in time during catheterization, improve the one-time placement rate, and ensure the safety of catheterization [13-14].

PICCs are punctured through the upper extremity vein, and the optimal position of the catheter tip is at the inferior V3 of the superior vena cava [15-16]. Chen Linglin et al. [17] showed that the one-time optimal position placement rate of neonatal PICC cavity electrocardiogram positioning was 82.5% and 95%, which showed that different P-wave amplitude interpretation standards would directly affect the one-time optimal position placement rate. In order to improve the one-time optimal position placement rate, the catheter tip position corresponding to the P-wave 1/3~1/2 R, 1/2~2/3 R, and 2/3~4/5 R bands was analyzed, and the results showed that when the P-wave was 1/3~1/2R, the catheter tip was mainly located in the upper 2/3 of the superior vena cava. The tip of the catheter is mainly in the recommended position, that is, the lower 1/3 of the superior vena cava; At 2/3~4/5R wave, the proportion of catheter tip position in the recommended position decreased compared with 1/2~2/3R and increased compared with 1/3~1/2R wave, and the difference between the three bands was statistically significant. The results showed that when the P wave amplitude was in the 1/2~2/3R band, the proportion of the catheter tip in the recommended position was the highest, that is, the first-time optimal position was the highest, which was consistent with the results of related studies [18]. For example, the tip of the PICC catheter is placed in the upper part of the superior vena cava, and the position of the catheter tip is too shallow and the catheter is easy to cause catheter displacement due to the growth of the child's body, so the position corresponding to the 1/2~2/3R band is the most ideal placement position for the newborn.

In summary, the tip positioning accuracy of neonatal PICC cavity ECG is high, and the catheter position can be dynamically analyzed during the operation, adjusted in time, and the one-time placement rate of catheter placement can be improved, the time spent on catheterization can be reduced, and the amount of blood loss at the puncture point can be reduced, among which, the 1/2~2/3R band is the best P-band for neonatal cavity ECG positioning.

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