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Study on *in Vitro* Accurate Measurement Method of PICC Insertion Depth

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Abstract

Objective to study an *in vitro* accurate measurement method for the placement depth of PICC. Methods 270 patients undergoing PICC catheterization under ultrasound guidance in outpatient PICC catheterization from March to September 2019 were selected by convenient sampling. By using the random number table method, the subjects were divided into group A (horizontal L-type measurement method) and Group B (characteristic index measurement calculation) by 1:1, with 135 cases in each group. X-ray chest radiograph was taken after catheterization in both groups, and the indwelling position of the catheter was adjusted according to the X-ray chest radiograph. The correlation between PICC predicted length and ideal depth and patient satisfaction were compared between the two groups. Results The success rate of PICC catheter tip insertion in group B was 97.78%, while that in control group A was 82.22%, the difference was statistically significant ($P < 0.05$). The satisfaction degree of patients in group B was significantly higher than that in group A. The differences were statistically significant ($P < 0.05$). Conclusion Improving the success rate of the precise depth of PICC catheter placement can significantly reduce the incidence of complications, waste of human and material resources caused by adjusting the catheter position, and significantly improve patient satisfaction.

Keywords

PICC, Placement, Depth, Characteristic Index, Measurement and Calculation Method

1. Introduction

Peripherally inserted central catheter (PICC) has the advantages of simple oper-

ation, safety, and low incidence of complications. It has been widely used in tumor chemotherapy, long-term intravenous infusion, intravenous nutrition therapy and other patients [1]. The use coverage rate of our department reaches 100%. The 2016 American Academy of Intravenous Care Guidelines recommends that the optimal location of the PICC catheter tip is in the lower third segment of the superior vena cava, near the junction of the superior vena cava and the right atrium (CAJ) [2] [3]. After successful catheterization, X-ray chest radiography is the gold standard for determining the location of the PICC tip. The location of the PICC tip is very important. If the catheterization position is too shallow or too deep, it is likely to cause catheterization related complications, such as phlebitis, catheter blockage, thrombosis, and arrhythmia [4] [5] [6]. So the depth control of PICC catheter placement is the key. At present, the length of PICC catheter placement in clinical practice is mainly determined by the body surface measurement method, with single indicators and inaccurate results. The effect of PICC placement is very dependent on the experience of the operator. There are several *in vitro* measurement methods commonly used in China. The length of the chest radiograph combined with body surface measurement formula [7] is not suitable for patients who have not taken a chest radiograph before catheterization. L-type measurement method [8] [9]: The patient was in a supine position with the arm extended 90˚, and the puncture point to the right sternoclavicular joint was used to reflexion downward to the third intercostal space. However, this method made the patients more exposed, and the difference was large for obese patients. The length of the brachiocephalic veins on both sides was inconsistent, which affected the accuracy of the length of catheterization. Caliper (formula) measurement method [10]: Height, selected vein and indwelling length are calculated according to the formula. This method is not suitable for those with a large difference in arm span and height ratio. The 201L edition of the American Society of Cancer Care recommends the use of Rountree's horizontal L-shaped measurement to predict the PICC catheter length for catheterization, but some studies show that this method is too long and too deep for catheterization. At present, the *in vitro* measurement of PICC is greatly influenced by the patient's body size, chest dressing, shoulder width, second and third intercostal width, vessel deformation, puncture site determination and other factors. At present, there are few studies at home and abroad using prospective studies to explore the ideal depth of PICC implantation *in vitro*. Through a large number of patients with body surface feature data, this study construct surface characteristic index system, comprehensive analysis of characteristic index and the depth of PICC catheter placement ideal correlation, establish ideal catheterization depth and the calculation model of key indicators, the formation of the depth of insertion control measures, guiding PICC catheter placement location and accurate, and reduce the additional risk of insertion, enhance catheter effect, reduce the incidence of complications, improve patient satisfaction.

2. Materials and Methods

2.1. General Information

A prospective randomized controlled design was adopted to divide the patients undergoing PICC catheterization under ultrasound guidance in outpatient PICC catheterization into group A (horizontal L-type measurement) and group B (measurement and calculation of characteristic indicators) by 1:1, 135 patients in each group. According to the general requirements of multi-factor analysis, the sample size should be 5 - 10 times the number of variables. Adding 10% shedding cases, the total sample size of the three groups N = 270 cases. The randomized controlled trial method was adopted, and the CHISS statistical software was applied to the unified random number table, and the patients were enrolled according to the sequence of PICC catheterization. 270 patients undergoing PICC catheterization under ultrasound guidance in outpatient PICC catheterization from March to September 2019 were selected by convenient sampling. By using the random number table method, the subjects were divided into group A (horizontal L-type measurement method) and Group B (characteristic index measurement calculation) by 1:1, with 135 cases in each group. There was no statistically significant difference ($P > 0.05$) between the two groups in age, gender, weight, left and right catheterization to measure limbs and other factors, indicating that the two groups were comparable. Inclusion criteria: Age ≥18 years; 1) It conforms to the indications of PICC implantation; Height 150 - 185 cm; Patients with informed consent, sign PICC catheterization consent. This study was approved by the ethics Committee of the hospital, and the patients signed informed consent, and were able to cooperate with the whole process of treatment and follow-up. Exclusion criteria: age <18 or >90 years old; 2) PICC catheterization contraindications; 3) Congenital dysplasia, vascular malformation; 4) severe scoliosis (Table 1).

2.2. Intervention Methods

All the selected patients were given catheterization in accordance with the standard procedure of PICC catheterization under the guidance of ultrasound: accurate height and weight were asked or measured for the patient; Group A (horizontal L-type measurement) : the patient was placed in the supine position, the arm abduction was measured by catheterization at A 90˚ Angle with the trunk, and the arm abduction was measured from the pre-puncture point to the right sternoclavicular joint and then reflexes downwards to the 3rd intercostal space. Group B (measurement and calculation of characteristic indicators): characteristic indicators were used for measurement: the catheterize accurately measured the patient's height, arm length, chest circumference, shoulder width, etc., and recorded the characteristic values (M1, M2, ···, Mn), according to the in depth calculation model for calculating the depth of insertion, as L = A + delta (L: catheter depth, A: feature index calculation values, Δ: special case compensation value), as A = + delta (M: single parameter measurements, β: to study the

Table 1. Comparison of general data between the two groups (N = 135, (X12 ± s)).

group	The number of cases n	gender	age $(\bar{x} \pm s)$	weight $(\bar{x} \pm s)$	left and right catheters for limb measurement $(\bar{x} \pm s)$
		Men women $(\bar{x} \pm s)$			
Observation group	135	72 ± 63	43.50 ± 8.50	2.80 ± 0.80	3.95 ± 1.07
Control group	135	66 ± 69	44.70 ± 7.60	3.10 ± 0.77	4.26 ± 1.24
X^2/t		0.18	0.71	1.81	1.27
p		0.67	0.48	0.07	0.21

characteristics of the correlation coefficient, n: the number of effective feature). Intervention trials were conducted with patients in the supine position, depending on their height. The arm abduction was measured by catheterization at A level of 90˚ from the trunk. First, the characteristic index was calculated as A. The right upper limb is inserted 1) in a patient with a height of 152 - 160 cm, and the catheter length is A1 + Δ1; 2) For patients with height of 161 - 168 cm, the catheterization length is A2 + Δ2; 3) For patients 169 - 178 cm in height, the catheter length is A3 + Δ3; 4) For a patient 179 - 185 cm in height, the length of the catheter is A4 + Δ4; Left upper limb inserted 1) in a patient with 152 - 160 cm height, the catheterization length is A1 + Δ1; 2) For patients with height of 161 - 168 cm, the catheterization length is A2 + Δ2; 3) For patients 169 - 178 cm in height, the catheter length is A3 + Δ3; 4) For a patient 179 - 185 cm in height, the length of the catheter is A4 + Δ4; Puncture catheterization and indwelling PICC under ultrasound guidance; Assist patients to take X-ray chest radiograph, and adjust the indwelling position of catheter according to X-ray chest radiograph; Detailed record of patient catheterization related information.

2.3. Observation Index

1) Correlation between predicted length and ideal depth in patients: After catheterization, X-ray chest radiograph was taken to determine that the PICC catheter tip was located in the lower 1/3 section of the superior vena cava, near the junction of the superior vena cava and the right atrium (CAJ), and the ideal location was determined.

2) PICC catheter tip location: the catheter tip may be located in the jugular vein, with subclavicular or axillary vein reflexes, or the catheter tip may be too shallow to reach the superior vena cava or the inferior segment of the superior vena cava. The catheter tip is located too deep beyond the junction of the superior vena cava and the right atrium into the right atrium (Table 2).

3) Patient satisfaction: The evaluation is carried out in the form of questionnaire, which is filled in by patients themselves or with the assistance of nurses. There are 10 items in the questionnaire, and each item has 4 options: very satisfied, satisfied and dissatisfied. The total satisfaction rate = (very satisfied cases + satisfied cases)/total cases × 100% (Table 3).

Table 2. Comparison of the success rate of PICC implantation in superior vena cava between the two groups (%).

Group	The number of cases (n)	Placed in superior vena cava (n)	Success rate (%)
Observation group	135	134	99.25
Control group	135	128	94.81

Table 3. Comparison of patient satisfaction between the two groups (%).

Group	The number of cases (n)	Very satisfactory (n)	Satisfaction (n)	Satisfactory (n)	Unsatisfactory (n)	Overall satisfaction rate (n)
Observation group	135	85	26	20	4	97.04
Control group	135	55	24	20	36	73.33

2.4. Quality Control

1) Catheter selection: the 4Fr three-way valvular single-cavity PICC of Bard Company was used;

2) Instrument selection: choose the vascular ultrasonic guidance system (Site—Rite5);

3) Operators: after unified training, and have the ARMY PICC pipe qualification;

4) Measurement requirements: each patient should be measured twice to determine the final length of catheterization;

5) Selection of blood vessels: the first choice is the expensive vein, followed by the brachial vein puncture;

6) Tip positioning: after the catheterization is completed, take X-ray chest radiograph to determine.

2.5. Statistical Methods

EpiData3.1 software was used to input the data, and the data was analyzed by SPSS17.0 statistical software. Measurement data were expressed as mean ± standard deviation, t-test was used, enumeration data were expressed as cases and percentage, X^2 test was used. Rank sum test was used for grade data, and $P < 0.05$ was considered statistically significant.

3. Results

1) Develop an *in vitro* measurement depth calculation model, which can more accurately describe the physical characteristics of patients, reduce the significant measurement deviation caused by subjective factors of nurses, and improve the accuracy of catheters depth.

2) Develop an *in vitro* measurement depth calculation model to provide theoretical basis for clinical application.

3) On the basis of the system and model, continuous feedback adjustment and optimization can be carried out through the measurement statistics of data, so as

to further optimize the calculation model of the tube depth and improve the accuracy according to the continuous accumulation of data.

4) The use of *in vitro* depth measurement model is conducive to the PICC catheter tip to reach the ideal depth

5) Improve the success rate of precise depth of PICC catheter placement, reduce the incidence of complications, waste of human and material resources caused by catheter position adjustment, and improve patient satisfaction.

4. Discussions

1) At present there are two kinds of PICC *in vitro* measurement method, namely L measurement method and caliper (formula) measurement method, the patients' body, dressing bandage, shoulder width, chest width between the second and third rib, vascular contorts, the puncture point to determine factors such as the impact is bigger, at home and abroad in ideal depth measurement by PICC prospective study to investigate *in vitro* research is less.

2) The optimal depth of PICC implantation is from the guiao vein, through the subclavian vein, through the intragonal vein, and to the third lower part of the superior vena cava. Due to the proportion of human body structure, the depth of implantation is correlated with the patient's body surface characteristics such as height, arm length and chest circumference. Therefore, it is theoretically feasible to construct a depth calculation model. It can provide an objective basis for popularizing the standard algorithm of *in vitro* measurement in the future.

3) There is 1 bed for catheterization in the PICC catheterization room of the outpatient department, and PICC nursing experts make home visits every day. There are 75 - 102 patients for catheterization every month, and more than 800 patients meet the inclusion criteria every year, which can ensure a sufficient sample size. Catheterization nurses all have PICC catheterization qualification of the PLA and are proficient in PICC catheterization technology. The members of the research group are composed of 2 associate chief physicians and 2 chief nurses, among whom 1 has a master's degree and 3 have a bachelor's degree. The members have a reasonable structure in terms of specialty, technology and age. The outpatient PICC catheterization room is equipped with complete equipment for relevant research.

4) The results of this study showed that the success rate of improving the precise depth of PICC catheter insertion in the observation group was significantly higher than that in the control group, indicating that the measurement and calculation method of characteristic indicators adopted by the observation group was significantly better than the current transverse L-shaped measurement method; It can significantly reduce the incidence of complications, waste of human and material resources caused by adjusting the catheter position, and significantly improve patient satisfaction.

To sum up, the characteristic indexes measuring method is superior to the method for measuring the horizontal l-shaped, have more advantages, can be

more comprehensive evaluate patients before catheter, effectively reduce the incidence of ectopic PICC catheter tip, high precision, and improved the PICC tip to superior vena cava under a third of the accuracy of patient satisfaction is high, reduces the waste of medical resources, economic spending, save the patient's clinical application significance, is worth popularizing widely.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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