



Operation Techniques of PICC Catheterization in Special Positions

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Abstract

Background: Peripherally inserted central venous catheter (PICC) is a reliable and safe method of central venous catheterization.

Objectives: This study aimed to investigate the operation techniques of PICC catheterization in special positions.

Methods: From January 2015 to August 2020, 52 cases in special positions were successfully catheterized and divided into four types. The characteristics of body positions, the principle of position placement and sterile sheet laying, the position of the operator, the evaluation before the catheterization, the preparation of related equipment for the catheterization, and the technical points of the catheterization operation were analyzed among these four types.

Results: By adopting different techniques (patient position placement, disinfection, sterile sheet laying, operator location, and operation key points) according to different patient positions, PICC catheters were successfully inserted in 52 patients.

Conclusion: When PICC catheterization objects cannot be placed in conventional positions, an individualized analysis should be carried out. According to the characteristics of their positions, special evaluation, position placement, disinfection and draping, and the preparation of special equipment to assist individualized catheterization operations should be carried out.

Keywords: Central venous catheterization, Operation technique, PICC, Position placement, Special position

1. Background

Peripherally inserted central venous catheter (PICC) is a reliable and safe method of central venous catheterization. Due to the low infection rate, it is suitable for patients who need intravenous access for several weeks to several months (1). In addition to the low infection rate, the advantages of PICC include being suitable for any fluid and long-term infusion, protecting peripheral blood vessels, and reducing repeated venipuncture. Some patients who are often severely ill due to the primary disease, combined with multiple diseases, cannot often tolerate the supine position, and can only perform PICC catheterization in a special position. If the catheterization is carried out in a special position, it may lead to the nonstandard laying of sterile sheets, which will affect the maximum sterile barrier effect, and it will also increase the difficulty for the operator, reduce the success rate of catheterization, and even interrupt the catheterization operation due to the patient's intolerance. Shingo Mitsuda (2) reported a case of catheterization in a patient with heart failure in a sitting position.

2. Objectives

Therefore, this study aimed to investigate the operation techniques of PICC catheterization in special positions.

3. Methods

3.1. General information

Patients who needed PICC were included in this study from January 2015 to August 2020. The characteristics of body positions, the principle of position placement and sterile sheet laying, the position of the operator, the evaluation before the catheterization, the preparation of related equipment for the catheterization, and the technical points of the catheterization operation were analyzed among these four types. This study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of our hospital. All participants had signed the informed consent.

The inclusion criteria were 1) stable vital signs, 2) indications for PICC catheterization, 3) willingness to undergo PICC catheterization, and 4) cooperation with the completion of PICC tube operation. On the other hand, the cases who were unable to cooperate with the completion of PICC catheterization operation, and those whose data were incomplete were excluded from the study.

3.2. Position placement, disinfection and towel laying, and operation points

3.2.1. Conventional position

The patient is placed in a supine position, with the limb abducted 45°-90°, and the elbow fossa facing upward.



Figure 1. A: The posture of the conventional position; B: The state of the conventional position after draping; C: The location of operator in the conventional position

Disinfection range: upper boundary, 15 cm at the proximal end of the upper 1/3 of the upper arm; lower boundary, 15 cm at the distal end of the lower 1/3 of the upper arm → use 2% chlorhexidine ethanol solution to disinfect the skin.

Towel laying: take a double-layer treatment towel to pad under the surgical limb → wrap the proximal end of the upper arm with a double-layer therapeutic towel → wrap the treatment towel around the hand and forearm → pass the orifice towel through the surgical limb to the proximal end of the upper arm and cover the whole body to maximize sterility barrier (Figure 1).

3.2.2. Special position: sitting position

Applicable patients: patients who cannot lie on their back or get out of bed due to severe wheezing.

Position placement: place an operating table in front of the chest of the patient, extend the surgical limb 60°-90° forward, with the elbow fossa facing upward, and place the surgical limb on the operating table. The scope of disinfection is the same as above.

Disinfection range: upper boundary, 15 cm at the proximal end of the upper 1/3 of the upper arm; lower boundary, 15 cm at the distal end of the lower 1/3 of the upper arm → disinfect the skin with 2% chlorhexidine ethanol solution.

Towel laying: take a double-layer treatment towel and place it on the front operating table → wrap the proximal end of the upper arm with a double-layer treatment towel → wrap the treatment towel around the hand and forearm → pass the orifice towel through the surgical limb to the proximal end of the upper arm and cover the whole body (including the head) to form a maximum sterile barrier (Figure 2).

Operating points: A) The operator is located in front of the patient and operates face-to-face. Place an operating table in front of the patient's chest, and the height of the operating table should be level with the patient's nipple. B) During the operation, keep the patient's head in a neutral position and face the opposite side. The patient can wear a mask when conditions permit to prevent contamination of the surgical field. C) After a successful puncture, if the delivery of the tube encounters resistance, assist the patient's arm abduction/or assist the patient's contralateral limb to rotate, aiming to convert the arm forward into the abduction and reduce the distortion of the axillary vein. D) The sitting position catheterization needs to be operated by nurses who are experienced in tube placement.

3.2.3. Special position: high Fowler's position

Applicable patients: patients who cannot lie on their backs due to severe wheezing, need support on their backs, and cannot get out of bed (3).

Position placement: place the operating table on the same side of the patient's surgical limb, with the surgical limb abducted 60°-90°, the cubital fossa facing upward, and the surgical limb on the operating table. The scope of disinfection is the same as above.

Disinfection range: upper boundary, 15 cm at the proximal end of the upper 1/3 of the upper arm; lower boundary, 15 cm at the distal end of the lower 1/3 of the upper arm → disinfect the skin with 2% chlorhexidine ethanol solution.

Towel laying: take a double-layer treatment towel and place it on the front operating table → wrap the proximal end of the upper arm with a double-layer treatment towel → wrap the treatment towel around



Figure 2. A: The posture of the sitting position; B: The state of the sitting position after draping; C: The location of operator in the sitting position



Figure 3. A: The posture of high Fowler's position; B: The state of high Fowler's position after draping; C: The location of operator in high Fowler's position

the hand and forearm → pass the orifice towel through the surgical limb to the proximal end of the upper arm and cover the whole body to form a maximum sterile barrier (Figure 3).

Operating points: A) The operator is located on the same side of the catheterized limb, and the catheterized limb is placed on the side operating table. B) The height of the operating table is under the patient's armpit so that the upper limbs are flush with the shoulders.

3.2.4. Special position: lateral position

Applicable patients: forced position due to pain or wheezing (patients who can only lie on one side).

Position placement: in principle, the puncture site is placed on the side limb that is not under pressure for a long time (to reduce swelling or thrombosis of upper limbs under long-term compression).

Position during disinfection: the patient is placed in a lateral position on the opposite side of the tube limb, and the surgical limb is abducted by 90°.

Disinfection range: upper boundary, 15 cm at the proximal end of the upper 1/3 of the upper arm; lower boundary, 15 cm at the distal end of the lower 1/3 of the upper arm → disinfect the skin three times with 2% chlorhexidine ethanol solution.

Position during draping: the patient is placed in the lateral position of the tube side limb.

Draping order: take the double-layer treatment towel and place it under the lateral position of the surgical limb → wrap the proximal end of the upper arm with a double-layer treatment towel → wrap the treatment towel around the hand and forearm → pass

the orifice towel through the surgical limb to the proximal end of the upper arm and cover the whole body to form a maximum sterile barrier (Figure 4).

Position when the tube is delivered: the patient is placed in a lateral position of the tube side limb (the surgical limb is facing down), and the surgical limb is extended 90°, with the cubital fossa facing upward.

Operating points: A) The limb on the side of the tube is placed below, the limb is extended 90°, and the operator is on the side of the surgical limb. B) When the tube is delivered, the assistant assists the patient to take the supine position (recommended time is no more than 1 minute) and then returns to the original lateral position after delivering the tube to the required length. C) ECG lead EKG locates catheter tip position.

3.2.5. Special position: shoulder stiffness position

Applicable patients: patients with shoulder stiffness.

Position placement: the patient is placed in a supine position, with the upper arm abducted by 30° (due to the limited movement of the shoulder joint), and the forearm is flexed at 60°-120°, which is conducive to the full exposure of the basilic veins. The wrist is tied to the head of the bed with a restraint belt.

Disinfection range: upper boundary, 15 cm at the proximal end of the upper 1/3 of the upper arm; lower boundary, 15 cm at the distal end of the lower 1/3 of the upper arm → disinfect the skin three times with 2% chlorhexidine ethanol solution.



Figure 4. A: The posture of lateral position; B: The state of lateral position after draping; C: The location of operator in lateral position



Figure 5. A: The posture of shoulder joint stiffness position; B: The state of shoulder joint stiffness position after draping; C: The location of the operator in the shoulder joint stiffness position

Sterile towels laying: take a double layer of sterile treatment towel and place it under the surgical limb → place a sterile tourniquet → wrap a long sterile treatment towel around the shoulders → wrap hands and forearms with a sterile treatment towel → remove gloves, disinfect hands → wear a sterile surgical gown, wear sterile gloves → lay a sterile large opening sheet through the surgical limb to cover the whole body → puncture the tube under ultrasound guidance (Figure 5).

Operating points: A) The operator is located on the side of the surgical limb. B) Bend the elbow at 90°, and the assistant assists the shoulder joint of the surgical limb to maintain maximum abduction and external rotation.

3.3. Statistical analysis

SPSS software (version 20.0, IBM, Chicago, USA) was used to conduct the statistical analysis. The continuous variables of normal and non-normal distribution were expressed as mean±SD and median

(interquartile range [IQR]), respectively. Moreover, the categorical variables were presented as frequency (percentage [%]). A value of $P < 0.05$ was considered statistically significant.

4. Results

4.1. General characteristics

The studied cases ($n=1162$) were catheterized in regular positions ($n=1110$) and special positions ($n=52$). Subsequently, the cases in special positions were successfully catheterized and divided into four types. The details were listed in Table 1.

4.2. The main outcomes

By adopting different techniques (patient position placement, disinfection, sterile sheet laying, operator location, and operation key points) according to different patient positions, PICC catheters were successfully inserted in 52 patients, and none of them had catheter-related complications.

Table 1. General information

Body position	Number of tubes	Male to female ratio	Age (years)	Puncture blood vessels				Reasons for the special position
				Basilic vein		Brachial vein		
				Left	Right	Left	Right	
Sitting position	8	5:3	58.50 ± 8.86	2	6	0	0	Unable to lie on the back due to massive pleural effusion, peritoneal effusion, and heart failure
High Fowler's position	16	7:9	61.62 ± 11.74	5	7	1	3	Unable to lie on the back due to massive pleural effusion, peritoneal effusion, and heart failure
Lateral position	5	1:4	55.80 ± 7.14	2	2	1	2	Pain or unilateral lung disease leading to forced posture
Shoulder joint mobility disorders	23	13:10	82.30 ± 8.31	5	9	4	5	Elderly and paralyzed patients with shoulder joint mobility disorders

5. Discussion

Patients need the long-term intravenous drugs (antibiotics, antifungals); patients need the drugs that are continuously administered or stimulate peripheral veins (vasoactive drugs, chemotherapy drugs); patients need the drugs that are hypertonic solutions (total parenteral nutrition).

Similar to the PICC indication recommended by Gonzalez R (1).

Bilateral clavicle fractures or vascular

malformations and a history of surgical trauma to the limbs on the side of the catheter are not included in the catheterization plan. It should be mentioned that the patients signed the informed consent before catheterization. Patients with massive pleural effusion, peritoneal effusion, and heart failure show forced end sitting or high Fowler's position due to the severity of the disease and the degree of tolerance. Patients with pain, unilateral lung disease, or unilateral pleural effusion lead to forced lateral position. Elderly and paralyzed patients with bilateral

shoulder joint mobility disorders often cannot be placed in a standard posture due to limited shoulder joint mobility.

The blood vessels in the sitting position and the high Fowler's position are the same as in the supine position. For patients with forced lateral positions, the tube should not be placed on the continuously compressed limb to avoid continuous compression of the limb with the tube. The non-compressed limb should be selected; otherwise, limb swelling and thrombosis are prone to occur. Patients with bilateral shoulder joint mobility disorders should choose limbs with greater mobility as much as possible. The principle of blood vessel selection is to use ultrasound to measure the diameter of the vein before catheter placement and select a catheter with a catheter-to-venous ratio $\leq 45\%$ (4). During the evaluation, the ultrasound probe should be traced along the blood vessel from the pre-puncture point to the axillary vein and internal jugular vein to assess the degree of vascular patency.

The conventional posture placement is to facilitate the catheterization operation and at the same time, facilitate successful catheterization. For the catheterization in a special position, postures should be placed in a position that the patient can tolerate, and the aseptic operation is strictly followed. According to the recommendations of the Association of periOperative Registered Nurses (5), sterile sheets are used to cover the patient's surgical limbs, operating tables, and related equipment in a sterile area. Before the PICC catheterization operation, the sterile sheet should be exposed to the scope of the operation field, including 5 cm under the elbow to 1/3 of the upper arm. The surgical limbs and forearms should be wrapped with sterile towels. The sterile sheet covers the operating table and the whole body of the patient to create a maximum sterile barrier.

Yuki Yamagami (6) found that after the application of tourniquets, compared to the supine position, the vein depth is deeper, the cross-sectional area is smaller, and it is less likely to be found and touched in the sitting position. Therefore, after the body position is placed, reassess the patient's comfort, blood vessel condition, operable space, and operator's convenience. The operator selects a suitable operating position for the catheterization operation according to different positions. After the catheter is placed, the position of the catheter tip is determined at the bedside by ultrasound and ECG lead EKG.

The study by Furlong-Dillard (7) confirmed that for novices who use ultrasound assistance, this PICC placement technique is not superior to chest radiographs in confirming the position of the catheter. Therefore, it is necessary to select experienced and skilled catheterization operators and assistants. According to a study by Moraza-

Dulanto (8), ultrasound assistance can significantly improve the success rate and reduce the incidence of complications. Gebauer (9) found that PICC placement under ultrasound guidance is simple and practical. A retrospective investigation by Nicholson (10) showed that the most benefited patients with ultrasound-guided PICC placement are those who have difficulty inserting the catheter into the vein for various reasons.

Therefore, it is recommended to use ultrasound for preoperative evaluation, intraoperative assistance, and postoperative evaluation. Visualization operations can increase the success rate of catheter placement. Many studies (11-15) confirmed that ECG lead EKG positioning is a cheaper, faster, and more accurate technique for PICC catheter tip positioning. Application of ECG lead EKG positioning can be accurate and timely at the bedside, thereby reducing the movement of patients with special positions and the possibility of PICC catheter re-adjustment. Therefore, it is recommended to use intraoperative ECG lead EKG to determine the position of the catheter tip, shorten the catheterization time, and avoid secondary adjustment of the catheter after the catheter is ectopic.

5.1. Intraoperative posture conversion technique

For catheter placement in patients with forced lateral position, if the patient is forced to recumbent on the right side, evaluate the vascular condition of the left limb before the catheter is placed and the time that the patient can tolerate in the left and horizontal positions. If the conditions are met, the catheter will be placed in the left decubitus position. After the puncture is successful, the assistant assists the patient in the supine position when the catheter is sent to the axillary vein. After the catheter is inserted to the required length, the patient returns to the left decubitus position and continues the follow-up operation.

If the vital signs change during the operation (e.g., too fast or slow heart rate, low blood pressure), terminate the catheterization operation in time and cooperate with the doctor for rescue (15-19). In addition, if the patient cannot tolerate and cooperate with the body position, the body position should also be adjusted. If the catheter is placed in a forced lateral position, the patient needs to lie supine for 1 minute. If the patient cannot persist, the catheter placement operation should be terminated.

5.2. Limitations of the study

There were several limitations in this study. Firstly, this study was a single-center trial, and another multiple center trial is still needed in the future. Secondly, the sample size of this study was really limited, and another larger trial with more participants is necessary.

6. Conclusion

When PICC catheterization objects cannot be placed in conventional positions, an individualized analysis should be carried out. According to the characteristics of their positions, special evaluation, position placement, disinfection and draping, and special equipment to assist individualized catheterization operations should be carried out.

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None.

Footnotes

Conflicts of Interest: The authors declare no conflict of interests.

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