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Application of Sitting Puncture Technique for Modified Midline Catheter Insertion in Patients with Acute Exacerbation of Chronic Heart Failure

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Abstract

Objective: To investigate the application of the sitting puncture technique for modified midline catheter (MMC) insertion in patients with acute exacerbation of chronic heart failure (AECHF), aiming to improve puncture success rate and patient comfort, thereby providing clinical evidence for patients who cannot lie flat due to disease but urgently require venous access. **Methods**: A retrospective analysis was conducted on 18 AECHF patients in our department from January 2022 to April 2025 who underwent MMC insertion using the sitting puncture technique due to intolerance to supine positioning. The key nursing considerations and experiences throughout the procedure were summarized. **Results**: Among the 18 patients, one procedure was discontinued due to poor vascular condition and worsening heart failure symptoms. The remaining 17 patients were successfully implanted with MMCs. All catheter tips were positioned in the subclavian vein, with indwelling durations ranging from 7 to 20 days, and no complications occurred. **Conclusion**: The application of the sitting puncture technique for MMC insertion in AECHF patients is feasible. It improves the success rate of catheterization and enhances patient comfort, leading to increased patient satisfaction and compliance with intravenous therapy, without increasing the incidence of adverse reactions.

Keywords

Sitting Puncture Method, Acute Exacerbation of Chronic Heart Failure, Modified Midline Catheter

1. Introduction

As a medium-length vascular access device, the midline catheter is widely used for patients requiring medium- to long-term intravenous therapy. The Modified Midline Catheter (MMC) is inserted through veins in the upper limb (such as the basilic vein, median cubital vein, etc.), with the catheter tip positioned at the subclavian vein [1]. According to the Infusion Therapy Standards of Practice by the Infusion Nurses Society (INS) [2], a midline catheter can be used when the anticipated duration of intravenous therapy is 1 to 4 weeks, based on the patient's treatment plan. This catheter, as a peripheral intravenous infusion tool, offers advantages such as a longer indwelling time, relatively fewer complications, ease of operation, and a reduction in repeated punctures [3]. Heart failure is a complex clinical syndrome caused by various factors leading to structural and/or functional abnormalities of the heart, resulting in ventricular systolic and/or diastolic dysfunction. Its main symptoms are dyspnea, fatigue, and fluid retention. Patients with acute exacerbation of chronic heart failure (AECHF) often cannot lie flat and may require a sitting position for breathing. Routine catheter placement requires the patient to be in a supine position, which can increase venous return, burden the heart, and induce or worsen chest tightness, shortness of breath, and dyspnea. Additionally, first-time catheterization patients may refuse to cooperate due to changes in comfort, increased cardiopulmonary burden, and anxiety or fear. Excessive anxiety may also cause vasospasm or difficulty in catheter insertion, and repeated attempts can lead to postoperative mechanical phlebitis. Therefore, the traditional supine position for catheter placement is limited in cardiology patients with AECHF, as they cannot tolerate lying flat. This may even trigger worsening chronic heart failure or an acute episode, prolonging the hospital stay.

Domestic venous therapy specialists have implemented a series of technical improvements and research on peripheral central venous catheterization (PICC) and midline catheterization techniques across different patient positions. Fu Jing *et al*. investigated the clinical outcomes of PICC placement under three distinct postures, demonstrating that the sitting position significantly reduced intravenous cannula displacement rates during catheter insertion. When adjustments were needed, the average number of catheter tip displacement corrections notably decreased. Notably, even when performed by experienced specialized venous nurses, this procedure maintained a 100% success rate for initial needle insertions. It is a safe and effective improved PICC catheter placement method [4]. Li Yaoli *et al*. explored the role of sitting position in correcting ectopic adjustment of peripherally inserted central catheter (PICC) in peripheral veins, and also showed that sitting position could effectively correct ectopic PICC catheter. This method is simple to operate and is worth clinical application [5].

This study retrospectively analyzes the data of AECHF patients in our hospital who received MMC insertion using the seated puncture method over the past three years, aiming to provide a basis for clinical practice. The seated puncture method, as a modified technique, can enhance patient tolerance, avoiding the res-

piratory distress and discomfort caused by the supine position. It expands the application scenarios of ultrasound-guided central venous puncture techniques, offering solutions for more patients with special positioning needs.

2. Materials and Methods

2.1. General Information

A retrospective analysis was conducted on the data of AECHF patients hospitalized in the cardiology department of our hospital from January 2022 to April 2025. A total of 18 patients who could not tolerate the supine position and thus received MMC insertion using the seated puncture method were included. Among them, there were 7 males and 11 females, aged between 58 and 94 years, with an average age of 75.06 ± 18.45 years.

Patients must me*et al*l of the following inclusion criteria:

Acute exacerbation of chronic heart failure (NYHA Class III-IV).

Documented inability to maintain a supine position (e.g., due to orthopnea, respiratory distress, or hemodynamic instability).

Clinical indication for midline catheter placement in a seated position.

Exclusion criteria: Patients who can tolerate conventional supine catheter placement. All patients underwent pre-procedural assessment of vascular access and comorbidities.

The modified midline catheter placement in a sitting position is a clinically established routine procedure that does not deviate from standard techniques. Operators were appropriately qualified, and the addition of a posture-assisting pad posed no additional risks to patients. As such, this retrospective chart review did not require ethical approval, as it involved no changes to conventional practices that could result in harm.

2.2. Methods

2.2.1. Pre-Procedure Preparation

Fully inform the patient and their family about the purpose and significance of the catheter insertion, potential adverse reactions, consequences, and management measures, and obtain informed consent. The doctor will issue an order for catheter insertion. Assess the patient's stability in vital signs and determine the most tolerable position. The patient should be in a semi-recumbent position (with the head of the bed elevated by 30˚ - 60˚), and receive continuous nasal cannula oxygen, along with continuous cardiac monitoring. Keep a close watch on indicators such as consciousness, respiration, blood pressure, and blood oxygen saturation. Use ultrasound to assess the venous condition of both upper limbs [6]. Based on the Dawson ZIM location method [7], select the "green zone" of the arm (from the medial epicondyle of the humerus to one-third of the way to the apex of the axilla) as the puncture area, with the basilic vein as the primary target vessel. Identify and mark the optimal puncture point of the target vein and its accompanying artery. Measure the circumference of the arm where the catheter will be inserted

and the pre-set catheter length.

2.2.2. Procedure Steps

Position the ultrasound machine on the side opposite to the catheter insertion side of the patient. Assist the patient in adjusting to a comfortable sitting position (with the back at an angle of 60˚ to 90˚ to the horizontal plane) and use a specially developed heart failure positioning cushion to support the back. Allow the arm on the catheter insertion side to hang naturally or rest on the table surface, fully exposing the puncture area.

Strict aseptic technique must be followed: The operator should perform hand disinfection, wear a gown, and put on sterile gloves. An assistant should pour 75% ethanol and 5% Andofor (povidone-iodine) antiseptic solution into a sterile container. The operator should first use 75% ethanol to disinfect the skin, rotating clockwise and counterclockwise in three rounds, centered on the puncture site, covering an area from the acromion to the wrist joint. Disinfect three more times using 5% Andofor in the same manner. Place a sterile drape under the arm. Apply a circular sterile tourniquet at least 10 cm above the puncture site. Lay down sterile drapes to maximize the sterile barrier. The assistant will help in passing sterile items. The operator should draw 0.9% saline and 2% lidocaine into syringes and arrange them in order of use. The assistant should insert the ultrasound probe, coated with coupling gel, into a sterile cover and place it in the sterile field.

Apply the tourniquet. Apply sterile gel to the puncture site. Use ultrasound guidance to locate the pre-determined vessel. The operator, with the left hand holding the ultrasound probe and the right hand holding the puncture needle (at an angle of 30˚ to 60˚), should pierce the vein and confirm successful puncture when blood returns from the needle hub. Fix the puncture needle and separate the probe. Insert the guidewire 15 - 20 cm into the vein with the right hand. Release the tourniquet and remove the puncture needle along the guidewire. Use a skin dilator to gently enlarge the puncture site along the direction of the guidewire. Insert the sheath assembly along the guidewire, then remove the guidewire, leaving the sheath in the vessel. Place sterile gauze under the sheath. Slowly and gently insert the catheter through the sheath into the vein to the pre-determined length. Aspirate blood to confirm the catheter is in place, then perform a pulsatile flush. Remove the sheath and the guidewire. The assistant should use ultrasound to confirm the catheter tip position (subclavian vein). Connect the positive pressure cap. Perform pulsatile flushing with at least 10 mL of saline and seal the catheter with positive pressure. Clean any blood at the puncture site, apply pressure with sterile gauze, and use a tension-free transparent dressing and an elastic bandage for compression and hemostasis.

2.2.3. Post-Procedure Care

Record information such as the time of catheter insertion, catheter model, insertion length, and puncture site. Provide detailed instructions to the patient and their family regarding post-catheterization care and maintenance. Assist the pa-

tient in finding a comfortable position and closely monitor their condition.

2.3. Results

Out of the 18 patients, the procedure was discontinued for 1 patient due to poor vascular conditions combined with worsening heart failure. The remaining 17 patients successfully had the MMC inserted, with the catheter tips positioned in the subclavian vein. The indwelling time ranged from 7 to 20 days, with no complications occurring during the period. Sixteen patients had their catheters removed on the day of discharge after recovery, and 1 patient was transferred with the catheter in place to a local hospital for continued treatment. Patient satisfaction was high, with no reports of significant pain or discomfort. In this study, successful catheter insertion was defined as the correct placement of the catheter tip in the target vein confirmed by either ultrasound or X-ray, with functional confirmation by aspiration of blood and unobstructed infusion. Complications were defined as any adverse events associated with the catheter during the indwelling period, including infection, thrombosis, phlebitis, dislodgement, leakage, or occlusion. These complications were assessed by daily monitoring and recorded in the medical and nursing records. Patient satisfaction was evaluated based on documented patient complaints or expressions of comfort in the medical records during the catheter indwelling period.

3. Discussion

3.1. Position Management

During the disinfection and puncture process, it is necessary to elevate the patient's upper limb on the catheter insertion side and to position it at 90˚ abduction and 60˚ external rotation during the procedure. This ensures that the ultrasound probe is perpendicular to the skin, providing a clear image. In the seated position, vessels may shift due to position changes; hence, the probe position needs to be adjusted dynamically. It is recommended to preferentially choose the relatively stable proximal basilic or brachial vein for puncture to minimize error. Studies have shown that [4] [5] seated peripherally inserted central catheter (PICC) placement can effectively reduce the rate of internal jugular vein malposition and the number of adjustments required, without affecting the first-attempt success rate for skilled operators. It is a safe and effective modified method.

Although there is substantial research on MMC application in China, studies specifically on seated MMC insertion are relatively lacking. Relevant guidelines recommend [8] the conventional supine position for puncture. Through this study, the modification to a seated position has improved both catheterization success rates and patient comfort. The reason for this is that in the seated position, with the shoulder above the level of the atrium, combined with the effect of gravity on blood flow, the catheter is guided to follow the bloodstream into the brachiocephalic vein and superior vena cava, reducing the risk of entering the internal jugular vein. Additionally, the seated position may increase the blood flow velocity

and return volume in the superior vena cava, and this flow can help propel the catheter downward smoothly. Many cardiology patients are elderly and have poor cooperation and tolerance levels. To overcome this challenge, this study enhanced psychological care (such as using narrative nursing to help patients recall positive experiences or employing supportive communication with delirious patients) and met patients' needs for position adjustments flexibly while strictly adhering to aseptic principles.

3.2. Analysis of Puncture Difficulty

Elderly bedridden patients often experience a reduction in subcutaneous fat, muscle relaxation, and sagging skin due to disease and malnutrition. In older patients, the vessel walls become thickened and hardened, the lumen narrows, fragility increases, and elasticity decreases, making the veins prone to movement, difficult to stabilize, and with more bifurcations. Some patients also have limb dysfunction, high muscle tone, limited upper limb abduction, or poor cooperation ability. Multiple puncture failures can lead to mental stress and vasospasm [9]. All these factors increase the difficulty of catheterization. In the seated position, gravity increases the resistance to blood flow downward. When encountering resistance while advancing the catheter, instructing the patient to slightly turn their head or adjust the arm angle can help avoid snagging on venous valves. Using a grip ball during the procedure to guide patient activity can help distract the patient and alleviate puncture pain.

3.3. Complication Prevention

Enhance aseptic procedures by using a 360˚ sterile drape to cover the patient's upper body, reducing the risk of contamination in the seated position. Replace dressings promptly according to regulations and maintain the catheter following expert consensus guidelines. Elderly patients often have multiple comorbidities and are in a hypercoagulable state, with reduced activity, increasing the risk of venous thrombosis. Patients should be instructed to elevate the limb on the catheter insertion side, avoid measuring blood pressure on that side, correctly time catheter flushing and sealing, and strictly implement positive pressure sealing. All personnel involved in catheter maintenance should receive standardized training to ensure transparent dressings are applied without tension and remain intact, dry, and clean.

3.4. Limitation

This study has several important limitations that warrant consideration. The relatively small sample size limits statistical power and the generalizability of the findings. As a single-center experience, our results may reflect institution-specific practices, patient demographics, or operator expertise that may not translate broadly to other settings. Crucially, the absence of a control group precludes definitive causal attributions regarding comparative efficacy and safety. Conse-

quently, while our findings suggest that seated-position PICC insertion is feasible and warrants further investigation in dyspneic patients, these results should be interpreted cautiously. Larger, multi-center, prospective comparative studies are essential to rigorously establish its safety profile, confirm benefits over standard approaches, and identify optimal patient selection criteria.

4. Conclusion

This study innovatively modified the body position for MMC insertion by employing the seated puncture method, and the results were favorable. The findings suggest that seated puncture for MMC insertion is particularly suitable for patients who cannot tolerate the supine position, especially those with AECHF. The seated position utilizes gravity to alleviate blood pooling in the lower limbs and abdomen, reducing cardiac preload, which helps relieve symptoms of dyspnea and chest tightness, thereby improving patient comfort. This method addresses the urgent need for catheterization in patients who cannot lie flat, increasing the success rate of catheterization and patient comfort, and consequently enhancing patient satisfaction and adherence to venous therapy. It should be emphasized that the seated puncture method requires a high level of technical skill from the operator, who must closely monitor changes in the patient's vital signs and be able to manage emergencies. MMC insertion is a peripheral venous procedure that is relatively simple, has a low complication rate, is cost-effective, and has high patient acceptance. For patients with AECHF whose conditions are easily altered, whose circulation is unstable, and who require short-term use of vasoactive drugs, seated MMC insertion is an effective solution for venous access.

Conflicts of Interest

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

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