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Catheterization of PICC through a superficial femoral vein for patients with superior vena cava syndrome using ECG positioning and ultrasound-guided technologies

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Abstract

Objective: We herein demonstrate the efficacy of PICC placement through a superficial femoral vein in patients with superior vena cava syndrome using ultrasound guidance and electrocardiographic localization. The treatment of PICC disconnection was also discussed.

Methods: The study enrolled 51 patients with superior vena cava syndrome. Ultrasound-guided technology and ECG positioning technology are employed to help these patients in catheterization. The puncture time, the number of punctures, and catheter tip position were recorded. The patient was followed up for at least 2 years. The complications and treatment during follow-up were recorded.

Result: The average puncture time was 32.13 ± 3.91 min. A total of 49 patients were successfully punctured once, while 2 patients failed in the first puncture. The main reason for puncture failure is that the inability of a guide wire to pass through. After the nurse removed the needle and pressed the puncture point until no rebleeding occurred, the puncture above the original puncture point was successful. X-ray examination revealed that the catheter tip was located in the inferior vena cava, above the diaphragm, near the right atrium. The success rate of catheterization was 100%. The visual analog scale (VAS) score was (2.44 ± 0.73) at the time of puncture, which was tolerable during the operation, and the patient did not complain of obvious pain following the operation. One patient developed complications of broken tube half a year after the puncture. Interventional physicians utilized angiography to locate the broken catheter.

Conclusion: It is safe and feasible to place PICC through a superficial femoral vein under ultrasound combined with ECG positioning technology in patients with superior vena cava syndrome.

Keywords

PICC, superficial femoral vein, ultrasonic, superior vena cava syndrome, ECG positioning

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Introduction

Superior vena cava syndrome is a group of symptoms caused by a partial or complete blockage of blood flow through a superior vena cava back to the right atrium.[1] A tumor is the leading cause of superior vena cava syndrome. Since most patients require chemotherapy, they need long-term intravenous access. Peripherally inserted central venous catheters (PICC) is a very mature and effective catheterization technology.[2,3] However, catheterization can only be performed through inferior vena cava due to the blockage of superior vena cava in patients with superior vena cava syndrome. The femoral and superficial femoral veins are the most prevalent veins employed for catheterization. The disadvantages of femoral vein, when

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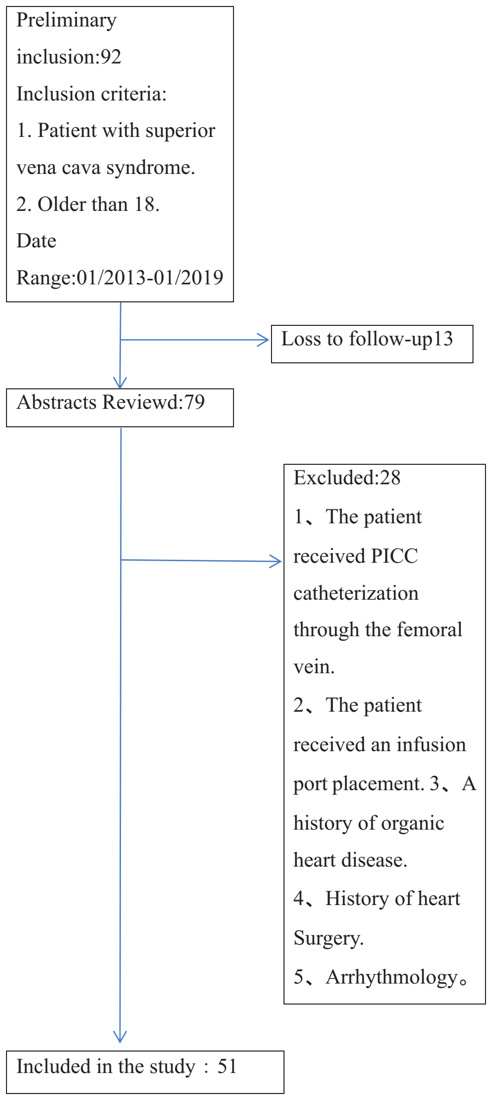
Table 1. The exclusion criteria and inclusion criteria.



used for a puncture, are easy contamination, and nursing complications. The superficial femoral vein was selected as the punctured vein as it exhibits disadvantages of long approach, numerous bifurcations, small lumen, and easy ectopic. Ultrasound is utilized to guide the puncture, and this technique, combined with electrocardiogram localization, can improve puncture accuracy. PICC catheterization has recently been implemented through a superficial femoral vein for patients with superior vena cava syndrome through ultrasound guidance and ECG localization technology, resulting in good efficacy.

Methods

We conducted a retrospective study (51 patients) between January 2013 and January 2020. The exclusion criteria and inclusion criteria are presented in Table 1. Compression caused by a malignant tumor is the cause of superior vena cava syndrome in these patients. CT scan was utilized to confirm that superior vena cava was compressed. The patients underwent more than two electrocardiograms before puncture to confirm their heart rate within the normal range. Two specialist nurses with more than 15-year working experience implemented PICC. Both nurses could read ECG results on ECG monitoring, and they mastered ultrasound-guided blood vessel puncture.

The patients were punctured in a particular operating room. The patient was placed in a horizontal position, and buttocks on the tube side were slightly raised. The lower limb of preset tube side was slightly abducted and circumflex, and the knee joint was slightly bent. The superficial femoral vein was found in the middle of thigh and selected as the punctured vein. The distance from umbilicus to xiphoid process was measured through the sacroiliac joint, and the length measured was the preset tube length.[4] After measuring 10 cm downward from the puncture point, a marking line was drawn, which is the tunnel direction. The thigh circumference of puncture point was also measured and recorded. The ECG monitor was adjusted in lead II. Electrodes are placed on patient's body, enabling ECG monitor to display the patient's heart rate. The nurse needs to reconfirm whether the patient exhibits normal sinus rhythm and retain the patient's basic rhythm waveform on ECG monitor. Iodophor is utilized to disinfect the skin around the puncture point. Color Doppler ultrasound is employed to guide blood vessel puncture. Nurses used modified seldinger technique for venipuncture. After a successful puncture, the catheter was trimmed according to the preset tube length and sent to the preset tube length, and then the cannula sheath was withdrawn. The nurse connected the catheter to the syringe and the heparin cap. The operator clamped the sterile RA electrode on the syringe needle and handed it to the assistant by aseptic manipulation. The assistant connected the sterile RA electrode clamp to ECG monitor. The operator continuously injects normal saline into the catheter to derive ECG. The two nurses observed the amplitude of P-wave and other characteristic waveform changes. Be careful that the two-way P-wave appears on the electrical monitor, freeze and save the waveform. At this time, the nurse needs to withdraw the catheter until the sharpest high P-wave appears. At this time, the nurse pulled out the guide wire and fixed the catheter. Lidocaine is utilized for local anesthesia, and the anesthesia area is the area just marked as the tunnel. Tunnel needles are employed in preparing tunnels. The catheter is guided by the tunnel needle in the tunnel where it is placed. After catheterization, the patient needs to go to the film room for X-ray examination. The puncture process is displayed in Figure 1.

Three specialist nurses with more than 5-year working experience took turns caring for catheterized patients. These nurses have received standardized maintenance training. The dressing was changed 48 h after the first catheterization. After that, patients received weekly maintenance if no complications occurred. Patients with complications such as

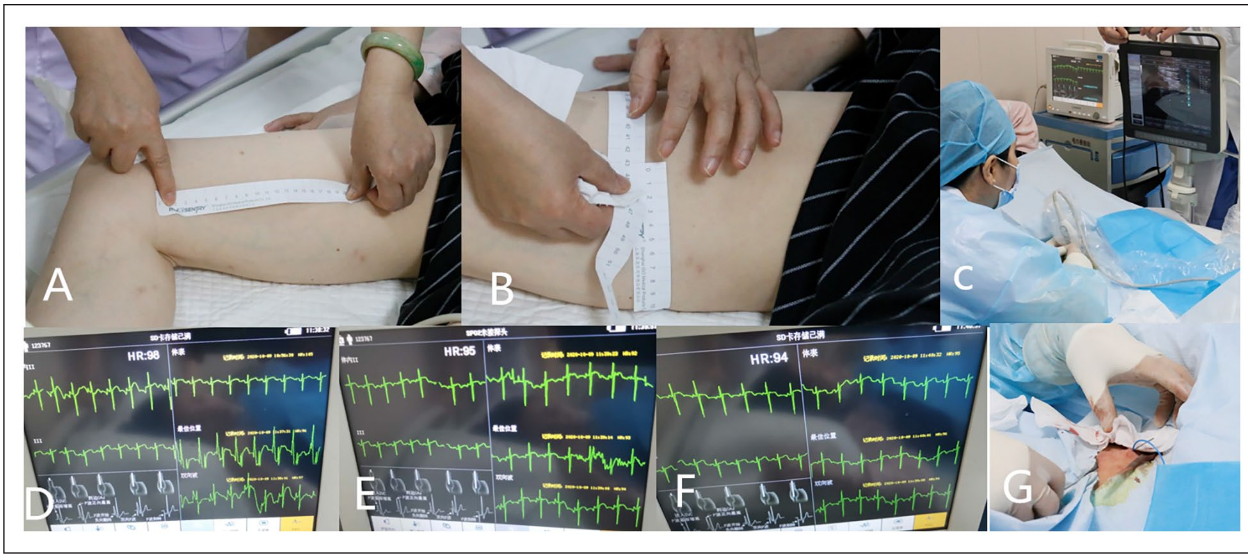


Figure 1. The process of puncture. A. The thigh circumference of patient B was measured. C. Nurses used color Doppler ultrasound guidance technology for blood vessel puncture. D. E, f ECG positioning technology is used for catheter positioning. When the catheter tip reaches the junction of superior vena cava and right atrium, the amplitude of P wave can be increased and widened to 50% - 80% of R wave amplitude or the level of P wave and R wave, indicating that the catheter position is the best.G.Tunnel needles are used to assist catheter placement

bleeding, exudation, catheter prolapse, and mechanical phlebitis should be maintained immediately.

The time from the beginning of evaluation of vessel to the completion of catheter fixation was recorded as the puncture time. The puncture times, the rate of puncturing in place, the catheterization success rate, the pain score, and postoperative complications were also recorded.

Values obtained from preoperative and postoperative visual analog scale (VAS) were compared with a 2-sample *t*-test. A significance level of $p < 0.05$ was utilized, and all results were presented as mean ± standard deviation (SD).

Results

The average puncture time was 32.13 ± 3.91 min. A total of 49 patients were successfully punctured once, while 2 patients failed in the first puncture because the guide wire cannot pass through. After the nurse pulled out the needle and pressed the puncture point until no rebleeding occurred, the puncture above the original puncture point was successful.

X-ray examination demonstrated that the catheter tip was located in the inferior vena cava, above the diaphragm, near the right atrium. The catheterization was success rate 100%. By January 2021, 23 patients had successfully indwelling PICC until the end of treatment period and extubated successfully. Six patients remained in the treatment period. The catheters were maintained regularly. No adverse complications such as thrombosis, phlebitis, blockage, catheter rupture, and catheter-related bloodstream infection were observed. Ten patients were in the end-stage of tumor. PICC catheter was utilized to the end of life. The Visual Analog Scale (VAS) score was (2.44 ± 0.73) at the puncture time, which was tolerable during operation, and the patient did not complain of evident pain after operation. One patient developed complications of a broken tube half a year after a puncture. The patient did not receive maintenance on time after catheterization because he later went to hospitals in other areas for anti-tumor treatment. The infection occurred about 5 months after catheterization. The patient received a local dressing change for nearly a month. During this period, the implanted tube still works until the wound on the surface breaks. The tube rupture occurred during debridement because the tube removal is difficult during the operation. Interventional physicians used angiography to locate the broken catheter. The catheter was found to be in its original position and did not move. Finally, the pipe was successfully removed. The removal process is presented in Figure 2.

Discussion

Patients with superior vena cava compression syndrome are caused mainly by lung cancer and other malignant tumors. They require long-term vascular access for irritant or corrosive drugs.[4] The femoral vein is located close to the groin and is not particularly clean. The femoral vein should not chosen as the puncture point since it is susceptible to infection.[5] As the joint moves, the groin regional catheter leads to vascular intimal injury. In addition, after catheterization, lower limb movement is limited, and blood flow is slow, increasing the risk of catheter-related infection and thrombosis.[6] Besides, it is challenging for patients undergoing femoral vein catheterization to return home with the catheter. Therefore, patients often require repeated catheter punctures, increasing pain and cost. The superficial femoral vein exhibits a relatively complex shape and many branches, infrequently chosen as a punctured vein in the past. However, as ultrasound technology has gained popularity, blood vessel puncture has become easier. In our study, most patients were successfully punctured. In

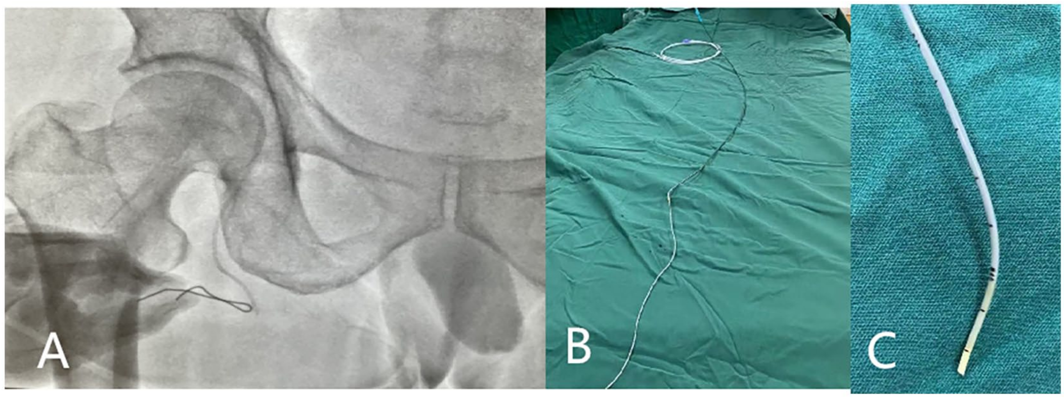


Figure 2. Color Doppler imaging of superficial femoral vein and great saphenous vein. A. The blue one is the superficial femoral vein, and the red one is the femoral artery. B.The blue one is the great saphenous vein, and the red one is the femoral artery. C. The blue one is the great saphenous vein, the red one is the femoral artery, and the place where the mouse stays is the superficial femoral vein

addition to our experience, ultrasound technology also assisted in keeping the patient's position unchanged.

ECG positioning technology also provides a guarantee for catheterization success.[7] The advantage of ECG location technology is real-time monitoring, imparting simplicity and feasibility.[8] In our study, all patients achieved good catheter placement, confirming the effectiveness of ECG localization technology.[9]

PICC catheter placement through superficial femoral vein has been widely used in children[10] but less in adults. The disconnection is a catastrophic complication, and tissue adhesion is the leading cause of this complication.[11] Phlebitis, venous spasm, and chemical vein stimulation may lead to catheter fracture.[12] In our study, infection occurred in patients with catheter fractures, and the soft tissue adhesion caused by infection makes it challenging to remove the catheter. Catheter drift may be secondary to catheter fracture. If the catheter drifts to the pulmonary artery with blood flow, dyspnea can follow as a fatal complication.[13] Therefore, X-ray examination should be arranged immediately after catheter fracture, and interventional physicians can use digital subtraction angiography (DSA) technology to remove the catheter.

Our study confirms that this technique can be employed in adults and imparts a good effect. However, this conclusion still needs to be confirmed by larger sample studies and future comparative studies.

Conclusion

It is safe and feasible to place PICC through a superficial femoral vein guided by ultrasound in conjunction with ECG positioning technology for patients with superior vena cava syndrome.

Disclaimer

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Ethical approval

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Informed consent

After our application, the informed consent was waived by the Ethics Committee of our hospital.

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