

# Effect of Evidence-Based Nursing Together with Nano-Silver Application on Central Venous Catheter Fixation in Critically Ill Patients & Effects of Related Complications

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## Abstract

This time, it uses electrostatic spinning technology to prepare nanofiber dressings to study their antibacterial effects, and to observe the occurrence of complications of catheter placement during central vein catheter (PICC) catheter maintenance with nanosilver dressing. Again, the effects of evidence-based nursing on central venous catheter-related adverse reactions in critically ill patients were studied. In this study, a kind of wound dressing with nano-scale scaffold structure also nano-silver loading was successfully prepared. Which results of in vitro bacteriostasis experiments showed that nano-silver application had better bacteriostatic effects on *S. aureus*, *Pseudomonas aeruginosa* and *Escherichia coli* standard strains. Through analyzing the clinical data of 80 patients undergoing central venous catheterization in our hospital, patients were randomly divided into control group and experimental group by whether or not to implement evidence-based nursing measures. Nanosilver application was applied to the critically ill patients in the experimental group Central venous catheter puncture point. Thus, these two groups were compared for catheter-related infections, local hemorrhage, catheter prolapse or rupture, catheter obstruction, arrhythmia, and angina pectoris. The incidence of catheter prolapses, rupture, catheter obstruction, arrhythmia, and angina pectoris were not different between the two groups statistically significant with value  $P > 0.05$ . The incidence of catheter-related infections and local bleeding in the evidence-based care group was lower than in the conventional care group, while the differences were statistically significant with value  $P < 0.05$ . It is concluded that the nano-silver dressing contains nano-scale stent structure and is wound dressing with good antibacterial ability. The application of evidence-based care to central venous catheters in critically ill patients may significantly reduce the incidence of complications which is worth of clinical application.

**Keywords:** evidence-based nursing; nano-silver application; PICC catheterization; complications

## 1 Introduction

The peripheral venous catheter (PICC) is mainly inserted through peripheral veins such as cephalic vein, basilica vein/vena basilica, and median elbow of upper elbow; at that meantime,

start a deep vein implantation, place the tip of the catheter on the lower third of the superior vena cava to the junction of the superior vena cava with the right atrium (Van et al., 2014; Kleidon et al., 2018; Daniel et al., 2018). As we are all acknowledged that it has the characteristics of safety and reliability, small trauma, long indwelling time, avoiding the pain, discomfort caused by repeated puncture to the patient; it contains good protective effect to patients with long term intravenous infusion chemotherapy, also patients with poor peripheral blood vessels. Clinical studies

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have found that PICC contains obvious advantages in tumor chemotherapy and intravenous supportive care. However, as a kind of invasive procedure, when it is stayed in the body for too long inflammation, PICC may cause complications such as mechanical veins, catheter obstruction, catheter ectopic / prolapse, thrombosis, puncture point infection, et al. (Sulav and Radheshyam,2018)

With the widespread use of central venous catheters in the clinic, central venous catheter related infection (CVCRI) has gradually become one of the main factors of nosocomial infections. The patient's body and quality of life had an adverse effect (Kum et al.,2008)

Although many wound dressings have been used in clinical practice to prevent infections, still few wound dressings can fully meet the multiple requirements of wound healing. For a good wound dressing, the way to prevent wound infection and promote wound healing is a key issue that needs to be solved. Nanofiber scaffolds prepared by electrospinning technology (hereinafter referred as electrospinning) have similar morphological characteristics to natural extracellular matrix (ECM): continuous ultrafine fibers, high surface volume ratio, high porosity and variable pore size distribution.(Meng et al., 2009) of which has been experimentally proven that it can stimulate cells to synthesize a variety of cytokines and growth factors, and promote cell growth and wound healing(Lu et al.,2009) However, only electrospun fibers are difficult to contain good antibacterial ability. Selecting appropriate antibacterial drugs and combining them with electrospun fiber dressings may produce ideal nano-silver dressings. In the selection of antibacterial drugs, nano-silver has been used in a variety of drugs & wound dressings because of its good bacteriostatic ability, and its good resistance, safety and allergy(Yang et al.,2011; Amro et al.,2000; Shin et al.,2007)Meantime, while PICC has strict requirements for aseptic operation and post-operation care. Improper care can lead to complications such as infection, clogging, prolapse or rupture of the catheter. With the development of nursing science, clinical nursing research on central venous catheterization has gradually increased, and effective nursing measures have been proven to reduce the incidence of concurrent infections in patients with central venous catheters(G.and M,2015)Evidence-based Nursing (EBN)(S et al.,2018) is a concept of nursing influenced by evidence-based medicine, which uses valuable, credible scientific research results as evidence to ask questions, find evidence, meantime

use the evidence to best implement care. EBN contains 3 elements, the most suitable nursing research basis that can be used, the nursing staff's personal skills & clinical experience, the patients' actual situation, values and aspirations (Hebert, 2018).

Nowadays, nursing researchers' home and abroad have done a lot of research to prevent CVCRI (Byrtet al.,2018; Hoedl et al.,2018; Bonell,1999), still rarely involve the application of nano silver dressings. In this study, polyacrylonitrile (PAN) was used as the precursor polymer, and nano-silver / carbon nano-fiber composite dressing (hereinafter referred to nano-silver dressing) was prepared by electrospinning technology also silver mirror reaction to observe its vitroantibacterial ability. Moreover, this study further applied the nano-silver application to the central venous catheter puncture site of nursing critically ill patients, again analyzed the clinical data of central venous catheterization patients admitted in our hospital to explore the evidence-based nursing in reducing central catheter-related infections significance, in order to guide future clinical and nursing work.

## 2 Material and method

### 2.1 General information

This time 80 patients with PICC catheterization from August 2018 to August 2019 were selected as the research subjects, including 43 males and 27 females; aged 31 to 55 years, with an average age of  $36.8 \pm 1.2$  years old; of which lung cancer there were 26 cases, in addition, 15 cases of colorectal cancer, 5 cases of gastric cancer, 10 cases of cervical cancer, 3 cases of esophageal cancer, 10 cases of breast cancer, 8 cases of ovarian cancer, 1 case of multiple myeloma, moreover 2 cases of lymphoma. In which, forty cases of basilica vein/vena basilica venous catheterization, 26 cases of median venous catheterization, 14 cases of cephalic venous catheterization were selected. While the effective indwelling time of PICC catheter was  $17 \sim 150$  days, with an average of  $(57.1 \pm 3.9)$  days, and the catheter insertion length was  $32 \sim 54$ cm, with an average of  $(31.2 \pm 5.1)$  cm.

### 2.2 Preparation and characterization of nano-silver coating

On this step, first weigh 3g of polyacrylonitrile (PAN) powder, then slowly add it to 25 mL of N, N-dimethylformamide (DMF) under magnetic stirring, stir for 5 h until the solution clear. Next, the prepared spinning solution was transferred to a 20 mL syringe, a piece of 20cm × 20cm thin aluminum

foil was laid on a grounded metal conductive plate; when a stainless-steel needle and a high-voltage electrostatic power supply were connected (ES30P-5W, Dalian High Voltage Research Co., Ltd. Company). During the experiment, 15 kV was used as the spinning voltage, and the distance between the needle and the receiving plate was about 15 cm. Total electrospinning process is operated at room temperature, also the filaments fall onto a rotating receiving drum.

Then the prepared PAN nanofibers are put into tube furnace, after pre-oxidation and high-temperature thermal cracking, the PAN fibers undergo medium-temperature carbonization & high-temperature carbonization to form a network carbon fiber structure. Moreover, during pre-oxidation, the temperature was raised to 250°C then kept for 2 h. Besides, during the pre-oxidation of PAN nanofibers, nitrile groups polymerize to form a network structure. This structure is a trapezoidal structure with good thermal stability, which prevents it from melting during the carbonization process. After the pre-oxidation is completed, high temperature thermal cracking is performed, the temperature of the pre-oxidation is increased from 250°C to 900°C.; then under the protection of high-purity nitrogen, naturally cooled to room temperature.

The prepared carbon nanofibers were transferred to a silver mirror reaction solution of 0.1 mol / L Ag (NH<sub>3</sub>)<sub>2</sub> 20 mL + 0.4 mol / L CH<sub>3</sub>CHO 1 mL, and left at ambient temperature for 24 h to obtain nano-silver dressing.

### 2.3 Antibacterial experiment of nano-silver dressing

*Staphylococcus aureus* (ATCC 25923), *E. coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 27853); nutrient agar culture, hydrolyzed casein agar medium, phosphate buffered saline (PBS, 0.03 mol / L, pH 7.2). With the above materials are provided by our laboratory.

Gentamicin was used as control group. For the prepared nano-silver dressing and gentamicin bacteriostatic paper cut into 6 mm diameter discs, each group of 10, using K-B, paper diffusion method to detect, bacterial concentration 0.5 Mai's unit. The broth medium was used in the test, for the reason this medium and the pH value are both fixed, the thickness of the agar plate is 4 mm, which may ensure the repeatability of the same flora detection. The bacteriostatic ring diameter > 7 mm is for bacteriostatic effect, and the bacteriostatic ring diameter is ≤ 7 mm for no bacteriostatic effect. All three repeated experiments had bacteriostatic

effect.

### 2.4 Catheterization and nursing method

Both groups of patients were selected from the single vena cava made by the German company Braun, and the subclavian vein was intubated to the superior vena cava by a professional physician. On the day of catheter placement, the skin at the puncture point was routinely disinfected with a conventional 1% iodophor (range around the puncture point, 10 cm in diameter), then folded with a sterile gauze block to compress the puncture point to prevent bleeding from the puncture point and facilitate the absorption of blood, further then covered with an aseptic sterilized transparent dressing to facilitate observation of bleeding. In the experimental group, the puncture site and the surrounding skin were cleaned with sterile normal saline after 24 hours of dressing change, the scope was the same as that of iodine disinfection, then covered directly with a nano-silver dressing. All post-intubation nursing operations are performed by senior nurses also strictly adhere to the principles of aseptic operation. If there is no special condition, patients in both groups will change medicine once a week. Furthermore, to observe the puncture site, surrounding skin when changing the catheter dressing, and record details. After all catheters were removed, bacterial culture was performed. At that meantime, peripheral blood was drawn from patients with fever during catheterization for specimen culture.

Speaking about the control group performed routine nursing measures on patients with a central venous catheter. Evidence-based nursing measures were used in the patients in the experimental group: ① clinical characteristics of patients with central venous catheter placement and corresponding nursing plans; ② establishment of evidence-based nursing issues, such as where to place central venous catheter Changes in mood, indoor environmental hygiene, selection and observation of puncture points, nutritional status, et al.; ③ Evidence-based support, looking for evidence-based support by consulting the literature and summarizing clinical nursing experience; ④ Evidence-based application, selecting effective placement of catheters, improving patients' adverse psychological emotions, conducting effective indoor disinfection, and selecting effective puncture points Strengthen patient nutrition and improve immunity.

Observe the incidence of adverse reactions such as infection, local hemorrhage, catheter prolapse or rupture, catheter obstruction, arrhythmia, and angina pectoris after central catheter placement in

both groups. While the patient is in the catheter, situation of the puncture point should be closely observed 3-4 times a day. Once the puncture point is red, swollen, painful, chills, or fever, peripheral venous blood and central venous catheter blood are drawn immediately. Moreover, the central venous catheter should be removed for bacterial culture, and the occurrence of catheter-related infections should be confirmed with bacteriological evidence. Local bleeding, exudate, and catheter rupture were based on visual observation. If the input of medicines and nutritional fluids is not smooth or the monitored indicators contain big changes, check whether the catheter is blocked. Arrhythmia and angina pectoris are based on the clinical symptoms of the patient and the changes in the electrocardiogram of ECG monitoring.

### 2.5 Statistical processing

SPSS 20.0 statistical software was used for data analysis while measurement data were expressed as  $\bar{x} \pm s$ ; and t test was used. Count data was expressed as rate and  $\chi^2$  test was used. With value  $P < 0.05$  was considered statistically significant.

## 3. Result and discussion

### 3.1 Morphological characterization of sample

Scanning electron microscope observation: The diameter of the prepared pure carbon nanofibers is about 200 nm, fibers are relatively straight, better separated, with the surface is smooth (Figure 1). Through the silver mirror reaction at room temperature, the diameter of the fiber became a little thicker, about 230 nm, also the surface of the fiber became rough, while the surface of the carbon fiber was covered with a layer of silver nanoparticles (Figure 2).

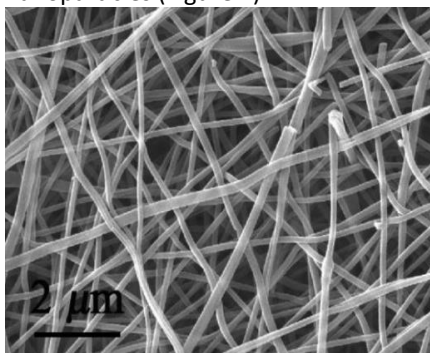


Figure 1. Scanning electron microscope image of carbon nanofibers.

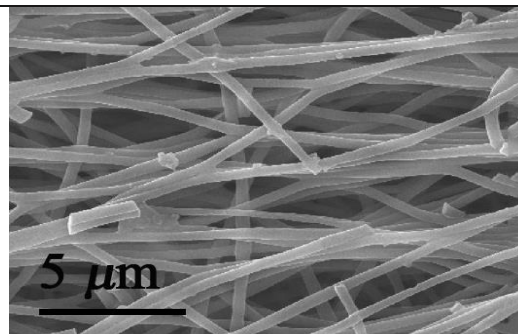


Figure 2. Scanning electron microscope image of silver-modified carbon nanofibers.

### 3.2 Antibacterial test

The experiment confirmed by KB paper diffusion method that the nano-silver dressing had good antibacterial effect on *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Escherichia coli*, and the antibacterial effect was better than gentamicin with significant differences between the comparisons ( $P < 0.05$ ). The experimental results are shown in Figure 3.

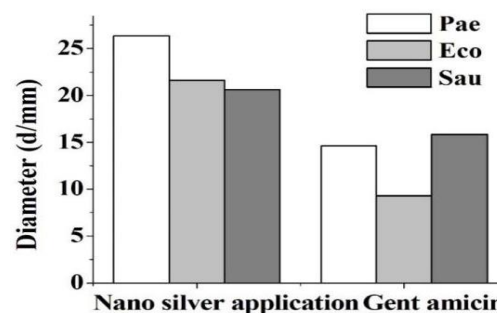


Figure 3. Antibacterial experiment results of each group

### 3.3 Clinical trial result

After 80 patients were placed through the central venous tube, the average tube take time was 42 days, and an average of 3.2 cycles of chemotherapy could be completed. Through active and effective nursing and aseptic knowledge education, patient compliance reached 96%, ensuring clinical chemotherapy and Smooth implementation of important rescue treatments. The comparison of various observation indicators between the two groups showed that the dressing replacement interval in the experimental group was prolonged by 1.7 days while compared with the control group. The incidence of local skin reactions at the puncture site decreased by 14.73%, while the incidence of CVCRI also decreased by 4.17%. There

are significant differences in comparison ( $P < 0.05$ ), with details check from Figure 4 to Figure 7.

Patients with local skin reactions at the puncture site and CVCRI were cured and discharged after local disinfection, anti-inflammatory treatment, and systemic antibiotic treatment.

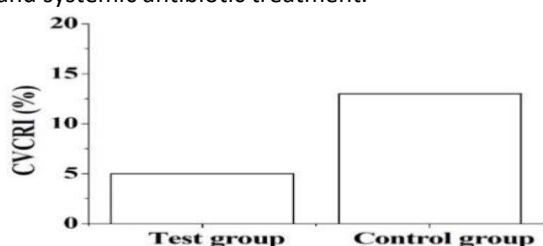


Figure 4. Comparison of dressing change intervals between the two groups

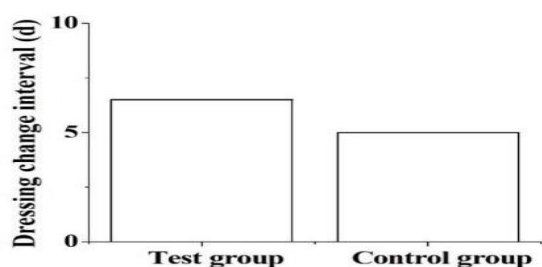


Figure 5. Comparison of CVCRI ratio between the two groups

Table 1. Comparison of complications between two groups of patients

Group	Puncture point infection	Phlebitis	Loose application	Catheter removal / dislocation
Control group	14	11	10	9
Test group	2	1	1	0
P	0.02	0.02	0.04	0.03

### 3.4 Nursing result

Of the 80 patients, 7 had adverse reactions in acute intubation, 16 had adverse reactions in elective intubation, and the difference was not statistically significant ( $P > 0.05$ ). 6 cases had adverse reactions in jugular vein intubation and subclavian there were 10 cases of adverse reactions in venous intubation and 6 cases of femoral venous intubation. The difference was not statistically significant while value  $P > 0.05$ . This shows that neither the timing nor the location of the catheter will affect the incidence of catheter-related adverse reactions. A total of 22 adverse reactions occurred in the routine nursing group and 6 cases of adverse reactions occurred in the evidence-based nursing group. The difference was statistically significant with value  $P < 0.05$ ; Catheter prolapse, rupture, and incidence of catheter obstruction, arrhythmia, and angina pectoris were not significantly different between the two groups ( $P > 0.05$ ); the incidence of catheter-related infections and local bleeding in the evidence-based care group was lower than in

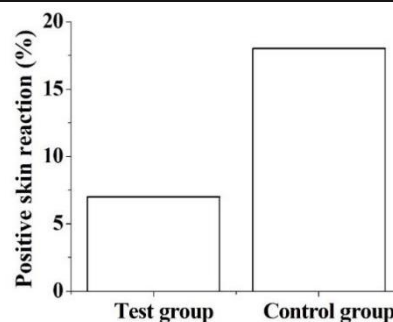


Figure 6. Comparison of positive skin reactions between the two groups

In the PICC catheterization and fixation technique, the incidence of PICC catheterization complications of puncture point infections and phlebitis were not statistically significant compared with the control group, and the incidence of loose application, catheter movement, and dislocation were significantly higher than those of the control group. The difference was statistically significant with value  $P < 0.05$ ; moreover, the comparison results of the complications between the two groups of patients are shown in Table 1.

conventional care Group, with the difference statistically significant ( $P < 0.05$ ), also details see Figure 7.

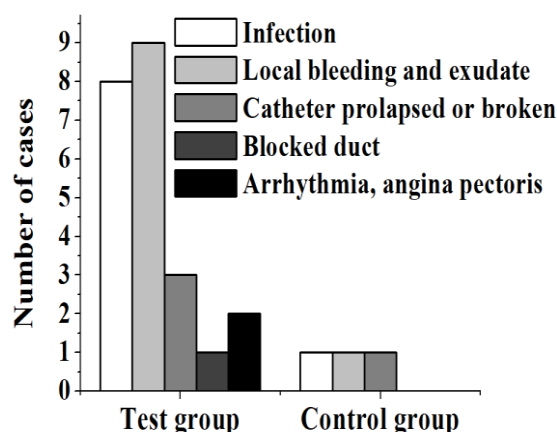


Figure 7. Comparison of adverse reactions between two groups of patients

### 3. Discussion

Evidence-based nursing was proposed by



McSherry et al;(McSherry et al.,2006) in 2006. Its production integrates political, professional & social factors, provides a new model for nursing work, which transforms the traditional nursing model based on experience into a modern nursing model based on science. As evidence-based nursing can save time, save costs also improve patient prognosis, it has become much more important in clinical practice. Therefore, the application of evidence-based nursing methods in nursing practice can play a positive role in promoting the development of Chinese nursing disciplines (Pinar et al.,2018).

Central venous catheters have been widely used in ICU, hence the complications caused by them have gradually attracted widespread clinical attention (Shadan and Khajehei,2019). Based on the latest & most reliable scientific evidence, evidence-based nursing provides targeted services to patients with central venous catheters (Berit et al.,2018), which effectively reduces the incidence of catheter-related adverse reactions. At that meantime, ICU patients are critically ill, and every aspect of care should be more careful, in this case it is particularly important to apply evidence-based care to ICU patients. Moreover, the central venous catheter is mainly placed in three different locations, including the internal jugular vein, subclavian vein, and femoral vein. Nursing staff may patiently explain the treatment process of central venous catheter placement to patients, also answer the questions patients have about the treatment process to eliminate the patient's fear of the condition, or the placement of the central venous catheter. At the same time, patiently explain the patient's ward environment and hospital regulations in a chat way, increase the patient's sense of security and compliance with clinical treatment, help patients adapt to the ward environment as soon as possible, so as to cooperate with clinical treatment since promote their early recovery. Every day, the indoor air is disinfected by ultraviolet rays, an air purifier is installed in the room for purification, and the floor is disinfected with a disinfectant solution. Meanwhile, the importance of maintaining personal hygiene is explained to the patient, and the patient is advised to keep the puncture site clean & dry. By the time when the puncture site is found to be swollen or indurated, replace the puncture site. In addition, caregivers should strengthen communication and exchanges with patients with central venous catheter placement, patiently explain the development of the condition to patients, and inform patients that treatment is a gradual process to enhance patient compliance with treatment and

improve clinical results. Due to the consumption of disease, patients with central venous catheters often have severe malnutrition, which threatens the patient's physical health and affects the progress of treatment. Therefore, patients should be instructed to eat high-energy, high-protein, easy-to-digest foods and eat less meals, while fasting spicy food (Kate et al.,2018). This time the results of this study indicate that the implementation of evidence-based and evidence-based care for ICU patients can significantly reduce the incidence of catheter-related adverse reactions. Moreover, evidence-based nursing supplements and improves the shortcomings of conventional nursing, and can promote the update of nursing staff's knowledge & scientific research level, hence it is worthy of clinical promotion even application.

Patients with malignant tumors, especially those in the middle or advanced stages, are prone to catheter-related infections due to factors such as neutrophil chemotaxis and reduced phagocytosis, severe bone marrow function suppression caused by long-term radiotherapy or chemotherapy, and skin damage caused by long-term use of indwelling catheters (Fajardo et al.,2015). According to reports, the incidence of bacterial colonization in the central venous catheter (CVC) is 5% -60%, while the incidence of CVCRI is 2% -43%. Further analysis found that the care of the catheter wound and strict aseptic technique after the placement of the catheter are the keys to preventing CVCRI. The wound dressing used in the clinic can protect the puncture point wound from being clean and sterile and prevent the catheter from moving freely or coming out. Clinical application shows that nano-silver dressing has antibacterial or bactericidal effects on more than 40 kinds of microorganisms such as *Staphylococcus aureus*, *Perfringens aerogenes*, *E. coli*, *Pseudomonas aeruginosa*, *Candida albicans* (SHE and Fu-qiang,2003; Sung et al.,2005; Ke et al. 2013; Fu-qiang et al.,2005) In this study, the incidence of CVCRI and the local skin-positive response rate at the puncture site were significantly lower in the nano-silver application group than in the control group, indicating that the nano-silver application was effective in preventing CVCRI in the care of central venous catheter wounds in critically ill patients. Nano-silver contains good hydrophilicity & stronger sterilization ability when exposed to water, therefore, it is only necessary to wash the wound and the surrounding skin with sterile normal saline when changing the dressing to apply it. It is easy to peel off when changing the dressing and does not damage the skin; hence the interval between dressings is effectively extended, which greatly

improves the efficiency of nursing work, meantime is worthy of clinical promotion also application.

#### 4. Conclusion

This time, in conclusion, nano-silver contains good hydrophilicity and stronger sterilization ability when exposed to water. It is only necessary to wash the wound and surrounding skin with sterile physiological saline when changing the dressing and apply it. Through that the total, patient feels comfortable, easy to peel off when changing the dressing, does not damage the skin, so the dressing interval is effectively extended, which greatly improves the efficiency of nursing work also is worthy of clinical promotion and application. Finally, the results of this study indicate that the implementation of evidence-based or evidence-based care for ICU patients may significantly reduce the incidence of catheter-related adverse reactions. At the same time, evidence-based nursing 'supplements & improves' the shortcomings of conventional nursing, and can promote the update of nursing staff's knowledge & scientific research level, so it is worthy of clinical promotion and application.

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