Journal of Biosciences and Medicines, 2025, 13(6), 75-82
https://www.scirp.org/journal/jbm
ISSN Online: 2327-509X
ISSN Print: 2327-5081

# Nursing Progress in the Management of Fibrous Sheath Complications in Patients with PICC Catheters

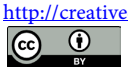
**Gaijing Wang[1*], Jie Cui[2*], Jing Wang[2], Lei Su[3], Miaomiao Song[1], Yanling Li[4], Yuanyuan Yang[1], Jiale Lu[1], Zhihui Cai[1], Fei Li[5], Haimei Ren[6#]**

[1]Department of Gynecology, Affiliated Hospital of Hebei University, Baoding, China
[2]Department of Obstetrics, Affiliated Hospital of Hebei University, Baoding, China
[3]Department of Radiotherapy, Affiliated Hospital of Hebei University, Baoding, China
[4]Department of Nursing, Affiliated Hospital of Hebei University, Baoding, China
[5]School of Nursing, Hebei University, Baoding, China
[6]Orthopedics Department, Affiliated Hospital of Hebei University, Baoding, China
Email: #627613039@qq.com

**How to cite this paper:** Wang, G.J., Cui, J., Wang, J., Su, L., Song, M.M., Li, Y.L., Yang, Y.Y., Lu, J.L., Cai, Z.H., Li, F. and Ren, H.M. (2025) Nursing Progress in the Management of Fibrous Sheath Complications in Patients with PICC Catheters. *Journal of Biosciences and Medicines*, **13**, 75-82.
https://doi.org/10.4236/jbm.2025.136008

**Received:** April 30, 2025
**Accepted:** June 7, 2025
**Published:** June 10, 2025







## Abstract

PICC is widely used in clinical practice due to its advantages of easy insertion, safety and cost-effectiveness, providing a reliable intravenous infusion pathway for patients undergoing chemotherapy, parenteral nutrition and home-based care. However, difficult catheter removal caused by fibrous sheath formation poses a significant challenge. This article reviews the current literature on the causes of fibrous sheath formation and nursing intervention strategies. Studies have shown that standardized PICC maintenance can reduce fibrous sheath formation. Low-dose urokinase and tPA-containing saline can improve recanalization rates to 95.3%. Salvia miltiorrhiza (Danshen) can inhibit sheath formation from the source. Patient education combined with monitoring can improve prognosis and reduce complications. These findings provide clinical nurses with practical guidelines to enhance PICC management safety and effectiveness, ultimately reducing patient harm and healthcare burdens.

## Keywords

Peripherally Inserted Central Catheter, Fibrous Sheath, Difficult Catheter Removal, Nursing

*Co-first authors.
#Corresponding author.

## 1. Introduction

Peripherally inserted central catheters (PICC) are inserted through the basilic vein, median cubital vein, cephalic vein, brachial vein, and external jugular vein in the upper limb, with their tips terminating in the superior or inferior vena cava, providing patients with a medium- to long-term intravenous infusion pathway. PICC insertion under ultrasound guidance is widely used in clinical practice due to its high success rate, labor-saving nature, time efficiency, minimal complications, ease of operation, safety, and reliability, as well as the lack of restriction on patients' upper limb movement [1]. This technique is widely used in clinical settings, such as chemotherapy, parenteral nutrition, and home-based care. Because it does not restrict upper limb movement and provides excellent protection for surrounding veins, it reduces the pain caused by repeated punctures. Therefore, it is well-accepted by patients. However, the use of PICC is associated with certain risks of complications, among which difficult catheter removal is one of the common problems in clinical practice [2]. Relevant studies have shown that the incidence of difficult PICC removal is 9.8% [3]. Difficult catheter removal is related to vasospasm, phlebitis, and the formation of fibrous sheaths. Among these, there is limited clinical experience in managing difficult PICC removal caused by fibrous sheaths [4].

Fibrin sheath complications are a significant clinical concern, with an incidence rate of 38% - 100% in PICC patients [5]. These complications not only affect the functionality of the catheter but also pose a risk of thrombus formation and infection. Therefore, understanding the mechanisms of fibrous sheath formation and implementing effective nursing interventions are crucial for improving patient outcomes and reducing the burden on healthcare systems. This article reviews the current research on the causes of fibrous sheath formation in PICC and the corresponding management strategies. The purpose is to provide clinical nurses with evidence-based preventive and therapeutic measures to reduce the incidence of difficult PICC removal. By preventing the formation of fibrous sheaths during catheter dwell time, we can avoid difficult catheter removal and minimize patient harm. This article also aims to offer a reference for nursing staff when dealing with such issues in the future.

## 2. Materials

### 2.1. Overview of Fibrous Sheath

Central venous catheters can lead to the formation of fibrous sheaths. The origin of the fibrous sheath is the contact point between the catheter and the vein wall, and it extends all the way to the tip of the catheter. This can affect the normal function of the venous catheter and is also prone to causing other complications [6]. The main components of the fibrous sheath include cellular and non-cellular elements, and it is a membrane-like substance that envelops the surface of central venous catheters [7]. Within 1 to 2 weeks after the insertion of a central venous catheter, the fibrous sheath rarely causes catheter dysfunction. However, as the dwell time increases, catheter-related complications may occur around 15 weeks

post-insertion. These complications include catheter blockage, extravasation, and catheter-related thrombosis [8].

### 2.2. Mechanism of Fibrous Sheath Formation

The formation of a fibrous sheath is a dynamic process. As the dwell time of the catheter increases, the composition of the fibrous sheath varies. It mainly includes fibrin, red blood cells, platelets, fibroblasts, endothelial cells, smooth muscle cells, collagen fibers, and elastic fibers [9]. After the insertion of a PICC catheter, injury to the vascular endothelium occurs, and continuous pressure is exerted on the vein wall. Additionally, with the patient's breathing, heartbeat, and physical movements, friction between the catheter and vein wall can cause endothelial damage. Endothelial injury, reduced blood flow velocity, and hypercoagulability of blood are crucial factors contributing to thrombus formation, and they also play a significant role in the development of fibrous sheath. Currently, there is no definitive conclusion regarding the formation of fibrous sheaths both domestically and internationally. However, existing research has indicated a correlation with catheter-related thrombus formation. The three key factors in thrombus formation are endothelial injury, slowed blood flow, and a hypercoagulable state. The development of fibrous sheath is a protective response of the human body to the invasion of foreign objects, such as a PICC catheter, and it is also a process of self-regulation and self-repair.

### 2.3. Reasons for the Formation of Fibrous Sheath Encasing PICC Catheters

A fibrous sheath is a catheter-related thrombus, distinct from the commonly referred-to mural thrombus. Unexpected displacement of the catheter can lead to treatment delays and thrombus formation, among other complications. PICC catheters are particularly prone to displacement [10]. Despite the high feasibility of PICC catheterization, patients undergoing PICC placement are susceptible to a variety of complications, such as infection, allergic reactions to transparent dressings, catheter blockage, phlebitis, and catheter insertion injuries. Therefore, during clinical treatment, it is essential to analyze the causes of these complications and provide targeted nursing care and interventions [11] [12]. Studies have identified key risk factors for fibrous sheath formation after PICC placement, including the type of infused fluid, infusion filter use, infusion rate, techniques for catheter flushing and locking, frequency of flushing and locking, and the specific tools employed for these procedures [13]. During the PICC insertion process, the vascular endothelium is injured, which activates the coagulation system and leads to endothelial cell damage. This, in turn, causes the adhesion of platelets and white blood cells and activates coagulation factors, resulting in the production of thrombin that converts fibrinogen into fibrin. However, because the catheter is a foreign body that is suspended within the blood vessel, it alters the original blood flow direction to varying degrees. This results in the accumulation of a large amount of fibrin around the catheter, leading to the formation of a fibrous sheath [14].

## 3. Nursing Care for Patients with PICC-Related Fibrous Sheath

### 3.1. Diagnosis of Fibrous Sheath in Patients with PICC Catheters

Currently, the primary diagnostic methods for fibrous sheaths both domestically and internationally include venography, CT scans, intravascular ultrasound, echocardiography, and histopathological staining [15]. Given the high detection rate and non-invasive nature of vascular ultrasound, it has become the most commonly used diagnostic tool for fibrous sheath in clinical practice. However, this method cannot accurately differentiate between fibrous sheath and thrombus, resulting in low specificity. Moreover, the accuracy of diagnosing fibrous sheaths using color Doppler ultrasound is not high [16].

Given that the early symptoms of fibrous sheath are difficult to detect, by the time they are identified, the sheath has often transformed into fibrous connective tissue, necessitating surgical removal, which can cause secondary injury. Therefore, it is suggested that Doppler ultrasound be combined with probe compression techniques for the clinical examination of fibrous sheaths to increase the positive detection rate [7]. Additionally, the integration of ultrasound with laboratory tests can be applied for the prediction of fibrous sheath formation [17].

Therefore, in the future, clinical nursing staff can adopt a multidisciplinary approach to the diagnosis of fibrous sheath. This can improve the diagnostic accuracy and prevent missed diagnoses.

### 3.2. Treatment and Nursing Care for Fibrous Sheath in Patients with PICC Catheters

At present, the most common method for managing fibrous sheath is pharmacological treatment, with the primary medications including urokinase, tissue-type plasminogen activator (t-PA), and streptokinase. Compared to streptokinase and t-PA, urokinase has fewer side effects and is more cost-effective, making it the conventional drug of choice for fibrous sheath [18]. Urokinase is a serine protease that directly activates plasminogen to promote fibrinolysis [19]. Some studies have shown that low doses of urokinase (1.5 mL, 15,000 IU) significantly reduce protein adsorption [20], while Ariyachaipan-ich *et al.* [21] demonstrated that adding 1 mg of tPA to 50 mL of saline for catheter recanalization can achieve a success rate of 95.3%. However, these medications do not address the root cause of the problem. Research by Tang Wenshuai has shown that within traditional Chinese medicine, Danshen (Salvia miltiorrhiza) possesses properties of promoting blood circulation to remove blood stasis, anticoagulation, inhibition of platelet aggregation, and vasodilation, which can inhibit the formation of the sheath from the source [22].

In clinical practice, the decision to use urokinase for thrombolysis or Danshen solution should be based on the individual patient's condition. It is important to note that during thrombolytic therapy, comprehensive monitoring of the patient's bleeding, coagulation, and platelet status is essential. Additionally, dissolving agents are not recommended, as they are ineffective against mature fibrous

sheaths [23]. If a patient has normal platelet counts and coagulation function, and Doppler ultrasound confirms the presence of a fibrous sheath while ruling out mural thrombus, successful catheter removal can be achieved after the administration of urokinase.

It should not be overlooked that excessive patient anxiety and tension can enhance sympathetic nerve excitability and repeatedly stimulate the vagus nerve, which can easily lead to vasospasm and contraction, thereby increasing the difficulty of catheter removal [24]. Therefore, nursing staff should provide detailed explanations to patients and their families about the causes of difficult PICC removal, coping strategies, and the purpose of the procedure before catheter removal. During the process, they should communicate with the patient to distract their attention and enhance the patient's trust in the nursing staff. This helps to alleviate anxiety and fear, preventing excessive nerve excitability from causing vasospasm or contraction, which could affect catheter removal. Additionally, nursing staff can use local warm compresses and massage to reduce the difficulty of catheter removal.

In the early stages, fibrous sheath formation does not present with obvious clinical symptoms and is difficult to detect. However, as it progresses to the late stages, it develops into fibrous connective tissue, at which point it cannot be managed solely with medication. In most cases, surgical removal of the catheter is required, causing secondary trauma to the patient. This highlights the importance of early prevention. Studies have shown that standardized catheter maintenance can reduce the incidence of fibrous sheath [25]. This is because the pressure difference generated during pulsatile flushing creates a vortex, and the swirling action can effectively remove adherent material from the catheter wall, reducing the risk of catheter blockage.Moreover, the swirling action is also detrimental to the formation of fibrous sheath. The water-injected surface protection technology plays a positive role in reducing protein adsorption. Water passes through the membrane wall into the bloodstream to form a blood-free boundary layer, preventing protein adsorption on the vessel wall and the formation of fibrous sheath [26]. Studies have shown that after infusing viscous fluids or blood products, nursing staff can effectively prevent the occurrence of fibrous sheath by using more than 10 ml of normal saline for pulsatile flushing and locking of the catheter, regularly observing the status of the indwelling catheter, strengthening health education, avoiding lifting heavy objects and prolonged pressure on the limb with the catheter, and regularly performing exercises with an electronic hand grip combined with fist clenching [27].

In practice, under the premise of meeting therapeutic requirements, selecting catheters with superior material and high biocompatibility for puncture can ensure adequate blood flow between the catheter and the vessel wall, thereby preventing the formation of fibrous sheath. Meanwhile, in the routine maintenance of the catheter, nursing staff should flush and lock the catheter more than three times a day (every 4 - 6 hours during infusion and every 8 hours without infusion) to avoid the formation of fibrous sheath. Additionally, it is essential to enhance

relevant training and management of nursing staff to ensure the safety and effectiveness of PICC catheter maintenance, prolong the lifespan of the catheter, and fully realize the application value of PICC placement [28].

## 4. Conclusion and Outlook

PICC catheters are easy to insert, safe, and cost-effective, effectively reducing the risks associated with surgical trauma. Therefore, they are widely used around the world [29]. However, some complications may occur, such as infection, catheter-related thrombosis, fibrous sheath, and phlebitis [30]. Studies have demonstrated that fibrous sheath formation is nearly ubiquitous among all types of central venous catheter access. Thus, the prevention of catheter-related fibrous sheaths and the extension of PICC usage have become hot topics in clinical practice.

Strengthening patient and family education on PICC complications is crucial. Detailed explanations of the causes, mechanisms, and solutions for catheter abnormalities, especially the formation of fibrous sheath, should be provided. This helps patients gain a better understanding and be more cooperative when complications arise, thus avoiding anxiety, tension, and fear.

Secondly, standardizing the relevant procedures is essential. PICC insertion and maintenance personnel must undergo rigorous training and obtain certification. During operations, adherence to protocols and mastery of proper flushing and locking techniques are crucial. Using normal saline for pulsatile flushing (a push-pause technique) before and after infusion can thoroughly clean the catheter, which is key to preventing catheter blockage [30]. During the infusion process, it is important to strengthen monitoring, carefully listen to the patient's complaints, and closely observe the condition. In case of extravasation, the infusion should be stopped immediately, the cause should be identified, and the patient should be managed in cooperation with the physician.

Lastly, the formation of fibrous sheath in PICC is related to the patient's underlying disease, the puncture method and process, as well as catheter maintenance and use. Therefore, before catheter placement, the patient's condition should be assessed, and the primary disease should be actively treated. During catheter placement, the choice of vein should be reasonable, and the skills of puncture and catheter insertion should be mastered. After catheter placement, standardized use and maintenance should be ensured. During infusion, close monitoring and timely cooperation with the physician for early management should be carried out to minimize the occurrence of catheter-related complications.

## Funding

This study was supported by the Medical Science Research Project of Hebei Provincial Health Commission (Project Number: 20220627).

## Conflicts of Interest

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

## References


[1] Johansson, E., Hammarskjöld, F., Lundberg, D. and Arnlind, M.H. (2013) Advantages and Disadvantages of Peripherally Inserted Central Venous Catheters (PICC) Compared to Other Central Venous Lines: A Systematic Review of the Literature. *Acta Oncologica*, **52**, 886-892. https://doi.org/10.3109/0284186x.2013.773072

[2] Glauser, F., Kivrak, S. and Righini, M. (2018) Peripherally Inserted Central Catheters: Indications, Contraindications, Complications. *Revue Médicale Suisse*, **14**, 2211-2213. https://doi.org/10.53738/revmed.2018.14.630.2211

[3] Chen, P., Wu, Q.-Y. and Wu, G.-M. (2009) PICC Decannulation Difficult Cause Analysis and Countermeasures. *Journal of Nursing*, No. 19, 71-72.

[4] Matusik, P.S., Łoboda, P., Krzanowska, K., Popiela, T.J., Heba, G. and Pawlik, W. (2020) Presence of Retained Calcified Fibrin Sheath after Central Venous Catheter Removal: A Systematic Literature Review. *The Journal of Vascular Access*, **23**, 644-652. https://doi.org/10.1177/1129729820969328

[5] Ni, N., Mojibian, H., Pollak, J. and Tal, M. (2010) Association between Disruption of Fibrin Sheaths Using Percutaneous Transluminal Angioplasty Balloons and Late Onset of Central Venous Stenosis. *CardioVascular and Interventional Radiology*, **34**, 114-119. https://doi.org/10.1007/s00270-010-9875-1

[6] Hoshal, V.L., Ause, R.G. and Hoskins, P.A. (1971) Fibrin Sleeve Formation on Indwelling Subclavian Central Venous Catheters. *Archives of Surgery*, **102**, 353-358. https://doi.org/10.1001/archsurg.1971.01350040115023

[7] Mogi, N., Nakagawa, M., Matsumae, H., Hattori, A., Shimohira, M. and Shibamoto, Y. (2018) Fibrin Sheath of a Peripherally Inserted Central Catheter Undepicted with Gray-Scale (Real-Time B-Mode) Ultrasonography: A Case Report. *Radiology Case Reports*, **13**, 537-541. https://doi.org/10.1016/j.radcr.2018.02.016

[8] Crain, M.R., Horton, M.G. and Mewissen, M.W. (1998) Fibrin Sheaths Complicating Central Venous Catheters. *American Journal of Roentgenology*, **171**, 341-346. https://doi.org/10.2214/ajr.171.2.9694448

[9] Roy, D., Wenxiang, Y. and Pande, S.D. (2020) A Calcified Central Venous Fibrin Sheath Mimicking a Fractured Catheter. *Seminars in Dialysis*, **33**, 343-344. https://doi.org/10.1111/sdi.12887

[10] Hughes, M.E. (2014) Reducing PICC Migrations and Improving Patient Outcomes. *British Journal of Nursing*, **23**, S12-S18. https://doi.org/10.12968/bjon.2014.23.sup1.s12

[11] Huo, J. (2021) Causes and Nursing Countermeasures of Common Complications after PICC in Cancer Chemotherapy Patients. *Guide to Family Life*, **37**, 98-99.

[12] Lyu, Q. (2017) Cause Analysis and Treatment Countermeasures of Complications after PICC Catheterization. *Family Medicine. Medical and Drug Selection*, No. 9, 193-194.

[13] Yang, M.L., Zheng, H.W., Mo, X.Z., *et al.* (2017) Cause Analysis and Nursing of 32 Cases of Fibrin Sheath after PICC Catheterization. *Journal of Mathematical Science and Medicine*, **30**, 941-942.

[14] Li, J., Su, M. and Wang, X.F. (2013) Nursing Care of Patients with PICC Catheter Wrapped by Fibrin Sheath. 2013 *Henan Province Intravenous Infusion Therapy Standardized Training Class and Academic Exchange Conference Proceedings*, Zhengzhou, 16 May 2013, 41-42.

[15] Tang, W.-S., Liao, H.-T., Liu, D., *et al.* (2017) Research Progress on Detection, Prevention and Treatment of Venous Indwelling Catheter Related Fibrin Sheath. *Nursing Research*, **31**, 2575-2579.

[16] Duan, Q.Q., Zhang, L.H., Zhang, W.Y., *et al.* (2012) Analysis of 28 Cases of Deep

Venous Catheter Fibrin Sheath Observed by Color Doppler Ultrasound. *China Blood Purification*, **11**, 198-201.

[17] Ling, Q., Chen, Y., Li, B.F., *et al.* (2021) Predictive Effect of Ultrasound Combined with Laboratory Examination on Fibrin Sheath Formation in Cancer Patients at Infusion Port. *Hebei Medicine*, **43**, 401-403+407.

[18] Cao, L.-P. and Yan, W.-N. (2017) Research Progress on the Mechanism of Fibrin Sheath Formation and Recanalization Methods of PICC Catheter. *Nursing Research*, **31**, 3912-3914.

[19] Wang, F., Peng, W., Xi, H.L., *et al.* (2021) Effect of Heparin Combined with Urokinase on Central Venous Catheter Sealing in Hemodialysis Patients: A Meta-Analysis. *Shanghai Nursing*, **21**, 16-21.

[20] Chang, D., Mammadov, K., Hickethier, T., Borggrefe, J., Hellmich, M., Maintz, D., *et al.* (2017) Fibrin Sheaths in Central Venous Port Catheters: Treatment with Low-Dose, Single Injection of Urokinase on an Outpatient Basis. *Therapeutics and Clinical Risk Management*, **13**, 111-115. https://doi.org/10.2147/tcrm.s125130

[21] Ariyachaipanich, A., Oyejola, O., Melhem, A., Soundararajan, V., Lerma, E., Atassi, W., *et al.* (2010) Tissue Plasminogen Activator Infusion as a Treatment for Hemodialysis Catheter Dysfunction. *Dialysis & Transplantation*, **39**, 97-99. https://doi.org/10.1002/dat.20417

[22] Tang, W.S. (2018) Effect of *Salvia miltiorrhiza* on Fibrin Sheath Associated with Venous Indwelling Catheter. Guangxi Medical University. (In Chinese)

[23] Duan, Q.-Q., Zhang, L.-H. and Wang, B.-X. (2011) Research Progress on Histopathological Characteristics and Pathogenesis of Fibrin Sheath in Central Venous Catheter. *Chinese Journal of Blood Purification*, **9**, 503-506.

[24] Shah, P., Khaleel, M., Thuptimdang, W., Sunwoo, J., Veluswamy, S., Chalacheva, P., *et al.* (2019) Mental Stress Causes Vasoconstriction in Subjects with Sickle Cell Disease and in Normal Controls. *Haematologica*, **105**, 83-90. https://doi.org/10.3324/haematol.2018.211391

[25] Fan, Z.Y., Yang, Y. and Chen, M.X. (2019) The Management of Difficult PICC Catheter Removal due to Fibrin Sheath. *Nursing Research*, **33**, 4171-4172.

[26] Sutherland, D.W., Blanks, Z.D., Zhang, X. and Charest, J.L. (2018) Relationship between Central Venous Catheter Protein Adsorption and Water Infused Surface Protection Mechanisms. *Artificial Organs*, **42**, E369-E379. https://doi.org/10.1111/aor.13274

[27] Zhang, M., Ma, Z.Z., Luan, S.L., *et al.* (2019) Observation on the Effect of Electronic Grip Device Combined with Clenching Fist Exercise on Improving Fibrin Sheath Related Catheter Dysfunction in PICC Cancer Patients. *Journal of Advanced Nursing Education*, **34**, 2268-2270.

[28] Chen, L.F., Li, J.Y., Yang, H.Y., *et al.* (2023) Training and Effectiveness of PICC Maintenance for Primary Nurses in Guangdong Province. *Chinese Journal of Nursing Education*, **20**, 194-199.

[29] Zhou, M.Y. (2023) Nursing and Reflection on a Child with Difficulty in Extubation Caused by Fibrin Sheath Formation after PICC Catheter Insertion. *Contemporary Nurses* (*The Last Ten-Day Issue*), **30**, 159-161.

[30] Long, Y.L. and Chen, L. (2017) Experience of 1 Case of PICC Catheter Fracture Caused by Difficulty in Extubation during Catheterization. *Contemporary Nurses* (*The Last Ten-Day Issue*), No. 1, 134-135.