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Ultrasound-Guided Tunneled Jugular Central Venous Catheterization in a Critically Ill Patient: A Case Report

Zhuqing Song[1*], Jie Chen[1], Fei Yan[2] and Ling Wang[1]

[1]Peking University Shenzhen Hospital, Shenzhen, China

[2]Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, Shenzhen, 518055, China

[*]**Corresponding author**: Zhuqing Song, Department of Breast Surgery, Peking University Shenzhen Hospital, Shenzhen, China

Abstract

This case report describes an evidence-based nursing approach for the insertion of a long subcutaneous tunneled jugular central catheter (LSJICC) in a critically ill patient, guided by the Knowledge-to-Action (KTA) Framework. The primary clinical objectives were to ensure uninterrupted treatment delivery, minimize catheter-related risks and complications, improve the success rate of central venous catheter (CVC) placement, and achieve the goal of “one catheter for the entire treatment course”. Through systematic identification of relevant evidence, translation of evidence into the local clinical context, and comprehensive assessment of facilitating and hindering factors, evidence-based guidelines were successfully applied to this case, including the selection of vascular access devices, insertion site, and catheter exit location. Guided by the KTA framework, a tunneled dual-lumen high-pressure resistant CVC was selected and inserted via the low jugular vein to balance infection risk, indwell time, and patient anatomy. The catheter remained in situ for 63 days, successfully fulfilling all infusion and hemodynamic monitoring requirements without complications such as malposition, displacement, dislodgement, fracture, or catheter-related infection. The patient was discharged with no post-removal complications. This case demonstrates the value of the KTA framework in implementing evidence-based CVC insertion practices and confirms that the tunneled jugular approach is safe and durable for long-term use in a

critically ill patient with complex vascular access challenges.

Keywords: Central venous catheterization; Tunneled catheters; Jugular vein; Evidence-based nursing; Critical care

Introduction

Central VENOUS CATHETERS (CVCs) are indispensable in the management of critically ill patients, providing essential vascular access for hemodynamic monitoring, administration of vasoactive medications, parenteral nutrition, blood product transfusion, and renal replacement therapy [1]. However, CVC placement in critically ill patients is associated with significant risks, including Catheter-Related Bloodstream Infections (CRBSI), catheter-associated thrombosis, mechanical complications (pneumothorax, arterial puncture, malposition), and catheter occlusion or dislodgement [2,3]. These complications not only increase morbidity and mortality but also prolong hospital stays and escalate healthcare costs [4]. The incidence of CVC-related complications varies considerably depending on multiple factors, including insertion site, catheter type, operator experience, and patient-specific characteristics such as anatomical variations, coagulopathy, and prior catheterization history [5]. Current evidence-based guidelines recommend that the selection of vascular access devices and insertion sites should be individualized based on the patient's clinical status, treatment requirements, and vascular anatomy, with the goal of minimizing complications and maximizing catheter durability [6,7].

In patients with limited vascular access options, due to prior catheterizations, thrombosis, anatomical constraints, or tissue edema, conventional CVC placement may be challenging or contraindicated. Tunneling techniques, which create a subcutaneous tunnel between the venous entry site and the catheter exit site, have been shown to reduce catheter-related infections and improve catheter stability by creating a physical barrier against microbial migration and anchoring the catheter away from the insertion site [8]. The jugular vein offers a viable route in critically ill patients, particularly when the risk of pneumothorax must be minimized; however, this approach demands considerable technical proficiency and careful site selection [9]. The Knowledge-to-Action (KTA) Framework, developed by Graham et al., provides a systematic approach to translating research evidence into clinical practice [10]. The framework comprises two main components: Knowledge Creation and the Action Cycle, which guides the application of knowledge through seven iterative steps from problem identification to outcome evaluation and knowledge sustainment. This structured process enables clinicians to integrate current best evidence into bedside decision-making while considering local contextual factors and barriers to implementation.

In the present case, an 83-year-old critically ill patient with severe pneumonia, COVID-19, and multi-organ dysfunction presented with a history of multiple CVC insertions complicated by occlusion, thrombosis, and suspected catheter-related bloodstream infection. The patient had difficult peripheral venous access, bilateral femoral CVCs in rotation for Continuous Renal Replacement Therapy (CRRT), and limited shoulder abduction, further complicating vascular access options. The primary challenge for the intravenous therapy nursing team was to secure a reliable CVC access that minimizes complications, extends indwell time, and ensures patient comfort while supporting the goal of "one catheter for the entire treatment course." To address this challenge, we applied the KTA framework to guide the evidence-based selection, insertion, and maintenance of a tunneled jugular central venous catheter. This case report describes the structured implementation process and clinical outcomes, with the aim of providing a practical reference for advanced practice nurses managing complex vascular access in critically ill patients.

Case Presentation

Patient Condition

An 83-year-old male presented with fatigue, sore throat, and fever after cold exposure on April 25, 2024. On May 3, he sought care at an outside hospital, where he developed acute respiratory distress with severe hypoxemia, requiring emergent endotracheal intubation, mechanical ventilation, and right jugular CVC placement. He received vasopressor support, anti-inflammatory agents, and antiviral therapy. On May 5, hemodialysis was initiated, and the patient was subsequently transferred to the Intensive Care Unit (ICU) at Peking University Shenzhen Hospital with the following admitting diagnoses: (1) severe pneumonia with type I respiratory failure, (2) COVID-19, (3) coronary artery disease, (4) multiple pulmonary nodules (etiology pending), and (5) multi-organ dysfunction syndrome.

Past Medical History: The patient had a history of coronary artery disease and multiple pulmonary nodules. No other chronic medical conditions were documented. The patient had no known drug allergies.

Psychosocial History: The patient had normal cognitive function and intact orientation. Family members provided emotional support and practical care, with a favorable family environment for rehabilitation.

Vascular Access History and Clinical Challenges

Upon transfer to our hospital on May 5, the patient underwent hemodialysis via a left femoral CVC placed at the referring hospital. He was admitted to the ICU, where he received prone positioning ventilation and supportive care. The patient's vascular access history and clinical challenges are summarized as follows: On May 25, the patient developed occlusion of the right jugular CVC. His VTE risk score was 6, and lower extremity Doppler ultrasonography confirmed deep vein thrombosis (D-dimer 2.45 mg/L), prompting initiation of anticoagulation therapy. He subsequently developed high-grade fever with positive blood cultures, and vancomycin was initiated for suspected catheter-related bloodstream infection. The occluded right jugular CVC was therefore removed, and a new CVC was inserted in the left jugular vein to enable transfusion of packed red blood cells and fresh frozen plasma. Meanwhile, a separate CVC was placed in the right femoral vein to allow site rotation with the left femoral CVC for Continuous Renal Replacement Therapy (CRRT).

By June 25, the patient had been mechanically ventilated for over 50 days, and the left jugular CVC had been in place for one month. The patient's vascular access challenges included: (1) a history of multiple CVC insertions with prior complications including thrombosis and occlusion; (2) difficult peripheral venous access due to severe upper limb edema (peripheral vein diameter <3 mm, capillary refill time ≈3 seconds); (3) bilateral femoral CVCs in rotation for CRRT, limiting lower extremity access options; (4) bilateral shoulder abduction limited to 40°, obscuring the axillary vein on ultrasound; (5) ongoing need for CRRT, blood product transfusion, and hemodynamic monitoring; and (6) the clinical goal of achieving "one catheter for the entire treatment course" to minimize repeated catheterizations and associated risks.

Diagnostic and Clinical Assessment

The diagnosis and management plan in this case were established through multidisciplinary consultation involving the Department of Critical Care Medicine, Department of Nephrology, Department of Infectious Diseases, and the Intravenous Therapy Nursing Team. The multidisciplinary team confirmed the patient's complex vascular access history, assessed the risks and benefits of various venous access options, and formulated an individualized plan for tunneled jugular CVC insertion guided by the KTA Framework. The patient's vital signs and key laboratory findings at the time of the procedure were as follows: body temperature 37.2 °C, heart rate 88 bpm, respiratory rate 20 bpm, blood pressure 135/72 mmHg, hemoglobin 95 g/L, platelet count 156 × 10^9/L, white blood cell count 11.2 × 10^9/L, D-dimer 1.89 mg/L, and albumin 32.5 g/L.

Nursing Care and Evidence-Based Implementation

Application of the Knowledge-to-Action (KTA) Framework

The KTA Framework was adopted to guide the evidence-based selection, insertion, and maintenance of the tunneled jugular CVC. The seven-step action cycle was systematically implemented as follows **(Table 1)**:

Table 1: Knowledge Application Cycle of the KTA Framework.

Seven Major Steps	Specific Content
Step 1: Identify the Problem	The patient required a durable and reliable central venous access device due to: (1) a history of multiple CVC insertions with prior complications including thrombosis, occlusion, and suspected catheter-related bloodstream infection; (2) difficult peripheral venous access (severe upper limb edema, vein diameter <3 mm); (3) ongoing need for CRRT, blood product transfusion, and hemodynamic monitoring; and (4) the clinical goal of "one catheter for the entire treatment course" to minimize repeated catheterizations and associated complications.
Step 2: Introduce	Based on current evidence, the following key points informed our decision-making: (1) CVCs

Knowledge to Specific Contexts	are indicated for patients requiring long-term parenteral nutrition, fluid therapy or hemodynamic monitoring [6]. (2) Upper extremity peripheral access is preferred over lower extremity to reduce thrombosis risk [11]. (3) The subclavian route carries lower infection and thrombosis rates but higher pneumothorax risk. (4) The jugular route avoids pneumothorax and is suitable for cachectic or respiratory-compromised patients [9]. (5) Tunneling techniques reduce catheter-related infections and improve catheter stability [8]. (6) High-pressure-resistant CVCs can meet various treatment needs, have a low risk of catheterization, and a low incidence of catheter-related bloodstream infections, making them suitable for use in critically ill patients [7]. (7) The 3CG® ECG-guided tip confirmation system enables real-time, accurate catheter tip positioning at the Cavo-Atrial Junction (CAJ) during insertion, reducing the need for multiple X-ray confirmations and minimizing radiation exposure [8].
Step 3: Assess Barriers and Facilitators	Barriers to Implementation: (1) Right subclavian CVC previously occluded; left jugular CVC in situ for one month with suspected infection. (2) Severe upper limb edema, peripheral vein diameter <3 mm, capillary refill time ≈3 s. (3) Bilateral femoral CVCs in rotation for CRRT, limiting lower extremity access options. (4) Bilateral shoulder abduction limited to 40°, obscuring the axillary vein on ultrasound. (5) High risk of bleeding due to anticoagulation therapy (D-dimer 1.89 mg/L). Facilitators: (1) Experienced ultrasound-guided vascular access team with specialized training in tunneling techniques. (2) Availability of tunneling devices and 3CG® tip confirmation system. (3) Multidisciplinary collaboration with critical care physicians, nephrologists, and infectious disease specialists. (4) Established evidence-based protocols and standardized operating procedures for CVC insertion and maintenance.
Step 4: Implement Intervention Measures	Based on the evidence and contextual assessment, the following intervention measures were implemented: (1) Device selection: A tunneled, dual-lumen, high-pressure resistant CVC was selected for insertion via the jugular vein. (2) Patient positioning: The patient's head was rotated left, with the shoulder elevated using a rolled sheet to expose the neck without overextension, minimizing the risk of venous collapse and inadvertent arterial puncture. (3) Ultrasound guidance: A high-frequency linear probe was aligned in the same axis as the jugular vein to provide real-time visualization of the puncture site, needle trajectory, and guidewire advancement. (4) Puncture technique: A low jugular approach was selected, with the puncture point pre-marked under ultrasound guidance. A pre-curved tunneler was shaped to match the

	neck-chest contour **(Figure 1)**. This tunneling technique aimed to: (i) create a physical barrier against microbial migration; (ii) anchor the catheter away from the insertion site to reduce dislodgement; and (iii) position the catheter exit site in a location that facilitates dressing changes and patient comfort. (5) Tip confirmation: Intraoperative tip positioning using the 3CG® ECG-guided system, which utilizes the P-wave morphology changes as the catheter tip approaches the Cavo-Atrial Junction (CAJ) **(Figure 2–3)**. Final tip position was confirmed at the CAJ by post-procedural chest X-ray, ensuring optimal function and minimizing the risk of arrhythmias or thrombosis. (6) Dressing and fixation: A sterile, transparent, semi-permeable dressing was applied to the catheter exit site to allow visualization of the site while maintaining a barrier against microbial contamination. The dressing was changed according to institutional protocol and whenever it became loose, soiled, or moist.
Step 5: Monitor Knowledge Application	Adherence to the following guidelines was monitored throughout the procedure and subsequent maintenance: (1) "Central venous access: Device and site selection in adults" **[12]**. (2) "Central venous access in adults: General principles of placement". (3) Infusion Therapy Standards of Practice, 9th Edition **[11]**. (4) Institutional protocol for CVC insertion and maintenance. Daily assessments included: (1) catheter site inspection for signs of infection, bleeding, or dislodgement; (2) catheter patency and functionality; (3) dressing integrity; and (4) patient comfort and tolerance.
Step6: Evaluate Outcomes of Knowledge Application	The tunneled CVC was successfully inserted in a 46-minute procedure, during which the patient remained hemodynamically stable. The catheter remained functional for 63 days, supporting intravenous therapy, blood product transfusion, hemodynamic monitoring, and CRRT, without catheter-related infection, thrombosis, occlusion, dislodgement, or mechanical complications. The catheter was removed uneventfully upon the patient's discharge **(Figure 4)**.
Step 7: Sustain Knowledge Use	A Standardized Operating Procedure (SOP) for ultrasound-guided tunneled jugular CVC insertion was developed based on this experience, followed by team education and competency training. The SOP includes: (1) indications and contraindications; (2) equipment preparation; (3) step-by-step insertion technique; (4) tip confirmation protocol; (5) post-procedural care; and (6) complication management.

Figure 1: Tunnel needle curvature adjustment: shaping the tunnel needle to address the physiological curvature of the neck (Patient Authorization).

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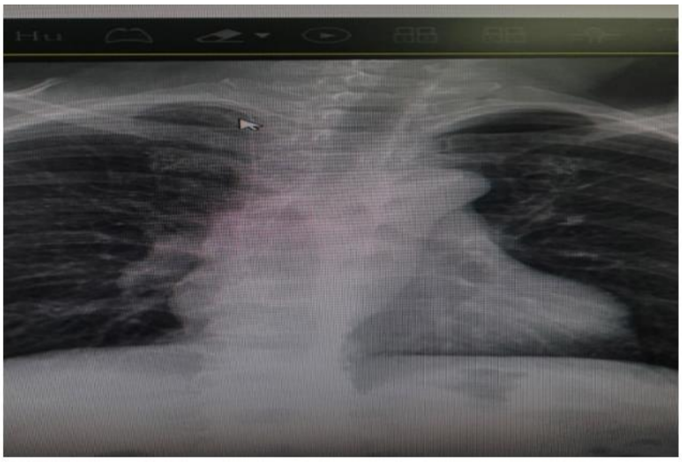

Nursing Care

Catheter Site Care: The catheter exit site was assessed daily for signs of infection, including erythema, swelling, warmth, pain, and purulent discharge. Dressing changes were performed using strict aseptic technique according to institutional protocol. The transparent dressing was changed every 7 days or when it became loose, soiled, or moist. The subcutaneous tunnel was gently palpated during each dressing change to assess for tenderness or induration.

Catheter Functionality and Patency: Catheter patency was assessed daily by observing blood return and infusion flow rates. The catheter was routinely flushed with normal saline using a pulsatile flushing technique to maintain patency. Anticoagulation therapy was closely monitored through regular assessment of D-dimer levels, platelet counts, and clinical signs of thrombosis.

Infection Prevention and Control: Strict aseptic technique was maintained during all catheter-related procedures, including dressing changes, blood sampling, and infusion connections. Hand hygiene was performed before and after every procedure. The catheter hub and injection ports were disinfected with alcohol-based chlorhexidine solution before each access. The patient's vital signs and inflammatory markers (white blood cell count, C-reactive protein, procalcitonin) were monitored regularly to enable early detection of catheter-related infection.

Patient Education and Psychological Support: Given the patient's prolonged ICU stay and complex treatment course, family members were educated on the importance of catheter care and the signs of potential complications. Psychological support was provided to both the patient and family members throughout the treatment course to address anxiety and maintain treatment compliance.

Clinical Outcomes and Follow-up

The patient's clinical course following tunneled CVC insertion was uneventful. The catheter remained in situ for 63 days, successfully fulfilling all infusion and hemodynamic monitoring requirements without complications. At the end of the treatment course, the patient's clinical condition had significantly improved: (1) body temperature normalized; (2) inflammatory markers decreased significantly (white blood cell count from 11.2 to 7.8 × 10^9/L, C-reactive protein from 45.6 to 12.3 mg/L); (3) D-dimer decreased from 1.89 to 0.56 mg/L; (4) albumin levels improved from 32.5 to 38.6 g/L; (5) the patient was successfully weaned from mechanical ventilation; and (6) CRRT was discontinued.

The catheter was removed uneventfully upon the patient's transfer to the general ward. No post-removal complications, including bleeding, infection, or thrombosis, were observed. The patient was subsequently discharged to a rehabilitation facility in stable condition.

Discussion

This case report demonstrates the successful application of the Knowledge-to-Action (KTA) Framework in implementing evidence-based tunneled jugular central venous catheterization in a critically ill patient with complex vascular access challenges. The structured approach enabled the clinical team to identify the optimal vascular access device, insertion site, and technique, resulting in a functional catheter indwelling time of 63 days without complications, supporting the goal of "one catheter for the entire treatment course."

Clinical Rationale for Tunneled Jugular Approach

The choice of vascular access device and insertion site in critically ill patients must balance multiple factors, including infection risk, thrombosis risk, mechanical complications, operator experience, patient anatomy, and treatment requirements [13]. In the present case, the patient presented with several factors that made conventional CVC placement challenging: a history of multiple CVC insertions with prior complications (occlusion, thrombosis, suspected infection); difficult peripheral venous access due to severe upper limb edema; bilateral femoral CVCs in rotation for CRRT, limiting lower extremity access options; and limited shoulder abduction, obscuring the axillary vein. The decision to place a tunneled CVC via the low jugular vein was based on a comprehensive assessment of the available evidence. Compared with non-tunneled CVCs, tunneled CVCs have been shown to reduce catheter-related infections by creating a physical barrier against microbial migration from the skin surface to the venous entry site [14]. The subcutaneous tunnel also anchors the catheter away from the insertion site, reducing the risk of accidental dislodgement and improving catheter stability [15]. This is particularly important in critically ill patients who may require frequent repositioning, prone positioning ventilation, or aggressive mobilization. The jugular approach was selected over the subclavian approach due to the lower risk of pneumothorax, which is especially relevant in patients with respiratory compromise [9]. The jugular vein also provides a relatively straight path to the superior vena cava and cavo-atrial junction, facilitating catheter tip placement at the optimal position for long-term use [16]. In addition, the low jugular approach allowed the creation of a long subcutaneous tunnel from the neck to the chest, positioning the catheter exit site in a location that facilitated dressing changes and patient comfort.

Integration of Ultrasound Guidance and Tip Confirmation Technology

The integration of ultrasound guidance and 3CG® ECG-guided tip confirmation technology was critical to the success of this procedure. Real-time ultrasound guidance has been shown to reduce mechanical complications, increase first-attempt success rates, and improve patient safety during CVC insertion [17]. In this case, ultrasound guidance was essential for visualizing the jugular vein, which was not readily palpable due to the patient's tissue edema and anatomical variations. The 3CG® ECG-guided tip confirmation system enabled real-time, accurate positioning of the catheter tip at the cavo-atrial junction during insertion, reducing the need for multiple X-ray confirmations and minimizing radiation exposure [18]. Accurate tip positioning is critical for long-term CVC function, as malpositioned tips are associated with increased risks of thrombosis, arrhythmias, and catheter dysfunction [19]. The combined use of ultrasound guidance and 3CG® technology in this case contributed to the successful placement and long-term functionality of the catheter.

Role of the KTA Framework in Evidence-Based Nursing Practice

This case report illustrates the practical utility of the KTA Framework as a structured approach to translating evidence into clinical practice. The seven-step action cycle guided our decision-making from problem identification to outcome evaluation and knowledge sustainment. The KTA Framework provided a systematic, transparent approach to clinical decision-making, which is particularly valuable in complex cases where multiple evidence-based options exist and individualized decision-making is required [10]. The clinical outcomes in this case compare favorably with published data on tunneled CVC outcomes. Studies have reported tunneled CVC infection rates of 0.5–1.5 per 1,000 catheter-days and thrombosis rates of 5–15% [20]. In this case, the catheter remained functional for 63 days without infection, thrombosis, or mechanical complications, demonstrating outcomes at least comparable to, and arguably superior to, published benchmarks. Recent case reports have highlighted the value of tunneled jugular

CVCs in patients with limited vascular access options, particularly in the context of hemodialysis and prolonged intravenous therapy [21]. However, few studies have systematically described the implementation process using a structured evidence-based framework such as the KTA Framework. This case report contributes to the literature by providing a detailed, step-by-step account of how evidence was translated into clinical practice in a complex, real-world scenario.

Nursing Implications and Clinical Practice Recommendations

This case has several important implications for nursing practice: (1) Role of Advanced Practice Nurses: This case highlights the expanding role of advanced practice nurses in vascular access management. The Intravenous Therapy Specialist Nurse conducted the comprehensive vascular access assessment, contributed to device selection, and participated in the insertion procedure, demonstrating that specialized nursing expertise is essential for optimizing vascular access outcomes in complex patients. (2) Multidisciplinary Collaboration: The successful outcome in this case was the result of effective multidisciplinary collaboration among ICU physicians, nephrologists, infectious disease specialists, and the intravenous therapy nursing team. This collaborative approach ensured that all relevant clinical factors were considered and that the selected intervention was aligned with the overall treatment goals. (3) Importance of Structured Evidence Implementation: The KTA Framework provided a systematic, transparent approach to clinical decision-making, ensuring that current best evidence was integrated into bedside practice while considering local contextual factors. (4) Patient-Centered Care: The tunneled CVC approach not only achieved the clinical goal of long-term reliable vascular access but also enhanced patient comfort and reduced the need for repeated catheterizations, contributing to an improved patient experience. (5) Knowledge Translation and Education: The development of a standardized operating procedure and team education program based on this experience will help sustain knowledge use and improve the quality of care for future patients with similar complex vascular access needs.

Limitations and Future Directions

Several limitations of this case report should be acknowledged. First, this is a single case report, and the findings may not be generalizable to all critically ill patients requiring CVC placement. The success of the tunneled jugular approach depends on operator expertise, patient anatomy, and institutional resources. Second, the follow-up period was limited to the duration of the patient's hospitalization (63 days); long-term outcomes beyond discharge were not assessed. Third, while the patient's clinical condition improved significantly during the treatment course, it is not possible to isolate the specific contribution of the vascular access strategy to the overall clinical outcome. Fourth, no formal psychometric assessment tools were used to evaluate patient comfort or satisfaction with the catheter, which would be valuable in future studies. Future research should focus on: (1) conducting larger-scale prospective studies to compare outcomes of tunneled versus non-tunneled CVCs in critically ill patients; (2) evaluating the cost-effectiveness of tunneled CVC strategies, particularly in patients requiring prolonged hospitalization; (3) developing validated patient-reported outcome measures for vascular access comfort and satisfaction; and (4) exploring the applicability of the KTA Framework in other areas of advanced nursing practice.

Conclusion

This case report demonstrates that systematic implementation of evidence-based CVC insertion practices, guided by the KTA Framework, can achieve durable and reliable central venous access in critically ill patients with complex vascular access challenges. The tunneled jugular approach—integrating low jugular puncture, subcutaneous tunneling, and 3CG® ECG-guided tip confirmation—proved safe, effective, and durable for long-term use, supporting the goal of "one catheter for the entire treatment course" and minimizing catheter-related complications. The successful outcome in this case underscores the importance of structured evidence implementation, multidisciplinary collaboration, and specialized nursing expertise in vascular access management. Advanced practice nurses are well-positioned to lead such initiatives, applying evidence-based frameworks to optimize clinical outcomes in complex patients. The KTA Framework provides a practical, systematic approach to translating evidence into clinical practice, which can be adapted to other areas of advanced nursing practice to improve patient outcomes and enhance the quality of care. The standardized operating procedure and team education program developed through this experience will help sustain knowledge use and improve the quality of care for future patients with similar complex vascular access needs. This case contributes to the growing body of evidence supporting the use of tunneled CVCs and structured evidence implementation in critical care nursing practice.

Authors' Contributions

Xiaoyan Huang and Zhuqing Song conceived and designed the study. Ling Wang performed the ultrasound-guided tunneling procedure and collected clinical data. Jie Chen and Shuping Quan contributed to data interpretation and evidence synthesis. Zhuqing Song drafted the manuscript. Xiaoyan Huang, Jie Chen, and Ling Wang critically revised the manuscript for important intellectual content. All authors reviewed and approved the final version and agree to be accountable for all aspects of this work.

Declaration of Conflicting Interests

The authors declare no competing interests.

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Ethics Approval and Informed Consent

This case report was conducted in accordance with the Declaration of Helsinki. Institutional review board approval was waived by Peking University Shenzhen Hospital for single case reports. Written informed consent was obtained from the patient for the publication of this report and any accompanying images.

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