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Summary of the Best Evidence for Puncture Management During the Early Stage of Autologous Arteriovenous Fistula in Maintenance Hemodialysis Patients

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Abstract: *Objective:* To retrieve, evaluate, and summarize the best evidence for puncture management during the early initiation stage of autologous arteriovenous fistula (AVF) in hemodialysis patients, providing a reference for clinical nursing practice. *Method:* Following the "6S" pyramid model system, evidence on puncture management during the initiation stage of AVF in hemodialysis patients was retrieved from domestic and international databases. The search included clinical decision-making tools, guidelines, evidence summaries, systematic reviews, and expert consensus. The retrieval period spanned from database inception to January 2023. Four researchers screened the literature, performed quality evaluations, and extracted and integrated the evidence. *Results:* A total of nine articles were included, comprising one clinical decision, five guidelines, one evidence summary, one systematic review, and one expert consensus. The evidence encompassed 18 key points across six areas: team building and personnel training, timing of initial puncture, pre-puncture evaluation, puncture methods, post-puncture pressure management, and management of puncture-related complications. *Conclusion:* Blood purification nursing staff should combine clinical scenarios with evidence-based medicine to adopt scientific, effective, and feasible puncture management strategies during the early initiation stage of AVF. This approach aims to better safeguard the patient's vascular access and overall treatment outcomes.

Keywords: Autogenous arteriovenous fistula; Early activation stage; Puncture management; Evidence summary; Evidence-based nursing

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1. Introduction

The autogenous arteriovenous fistula (AVF) offers the advantages of long-term usability and a low risk of

complications, making it the preferred vascular access for maintenance hemodialysis (MHD) patients [1,2]. Following AVF surgery and a maturation period of 8–12 weeks, the first 5–10 punctures after maturation represent the early activation stage, commonly referred to as the "new fistula" [3]. However, due to the anatomical characteristics of thin blood vessels, high pressure, and deeper positioning relative to the skin [4], puncturing AVFs at this stage presents significant challenges for clinical nurses, especially when urgent use of immature AVFs is required.

Unsuccessful puncture during the early activation stage is considered an independent predictor of early AVF failure [5]. Hill *et al.* [6] reported that within the first six weeks of AVF activation, 67.5% of patients experienced puncture failure, and 40% exhibited exudation or insufficient blood flow during dialysis, necessitating re-puncture.

To address these challenges, various measures have been explored to improve the success rate of puncturing new AVFs. These include the use of color Doppler ultrasound for detecting fistulas [7], dialysis indwelling needles for puncture [8], small-sized fistula needles [9], and centripetal puncture techniques [10]. Although these studies provide valuable insights, the evidence remains scattered and incomplete.

This study employs evidence-based methodologies to systematically retrieve, evaluate, and summarize existing literature, providing standardized and comprehensive management strategies for puncture during the early initiation stage of AVFs. By integrating the best available evidence, this research aims to support clinical nursing practice and improve the overall success rate of new fistula punctures.

2. Materials and methods

2.1. Establishment of research group

A research team comprising nine members was established, including four professionally trained evidence-based methodology personnel, one chief nephrologist, one head nurse of a blood purification center, two nationally certified blood purification specialist nurses, and one nurse trained in ultrasound. The responsibilities of each member were clearly defined. The four evidence-based methodology experts were responsible for identifying research questions, developing literature search strategies, establishing inclusion and exclusion criteria, conducting quality evaluations of the literature, and extracting evidence. The remaining members assisted the evidence-based experts in adjusting search terms, extracting evidence, and integrating and evaluating the final evidence.

2.2. Determination of the problem

Evidence-based questions were formulated using the PIPOST model:

(1) Target population (P): Patients with arteriovenous fistula.
(2) Intervention methods (I): Management of arteriovenous fistula puncture.
(3) Evidence application personnel (P): Medical staff and patients.
(4) Outcome (O): The success rate of first-time puncture for new fistulas, the incidence of hematoma in new fistulas, and nurse-related knowledge scores.
(5) Setting (S): Hemodialysis units.
(5) Type of evidence (T): Clinical decision-making tools, guidelines, evidence summaries, systematic reviews, and expert consensus.

2.3. Literature retrieval strategy

In accordance with the "6S" evidence resource pyramid model, Chinese keywords such as "hemodialysis/

maintenance hemodialysis," "vascular access/arteriovenous fistula," and "management/evaluation/puncture/compression" were used. English keywords included "renal dialysis/maintenance dialysis," "vascular access/arteriovenous fistula," and "management/evaluation/puncture/compression." Databases and sources searched included BMJ Best Practice, UpToDate, Cochrane Library, JBI Database, the National Institute for Health and Care Excellence (NICE, UK), the Ontario Nursing Association (Canada), the International Guidelines Network, DynaMed, the National Guidelines Clearinghouse (US), the Interhospital Guidelines Network (Scotland), the American Medical Association Guidelines Library, and professional association websites such as the European Renal Association-European Dialysis and Transplant Association (ERA-EDTA), the British Renal Society, the Japanese Society for Dialysis Therapy, and the National Kidney Foundation (US). Additional searches for relevant literature on arteriovenous fistula puncture management were conducted in PubMed, Embase, Medline, CINAHL, Web of Science, China Biomedical Database, CNKI, Wanfang Database, VIP Database, and Yimaitong. The retrieval period spanned from database inception to January 2023.

2.4. Literature inclusion and exclusion criteria

Inclusion criteria:

(1) Research subjects were hemodialysis patients aged ≥ 18 years.

(2) Research topics included new fistula puncture and evaluation.

(3) Research types included clinical decision-making tools, guidelines, evidence summaries, systematic reviews, and expert consensus.

(4) Literature published in Chinese or English.

Exclusion criteria:

(1) Full-text articles that could not be obtained.

(2) Outdated guidelines and expert consensus.

(3) Duplicate or translated publications.

2.5. Literature quality evaluation

The quality of the included literature was evaluated as follows:

(1) Guideline literature was assessed using the "Appraisal of Guidelines for Research and Evaluation II (AGREE II)" system (updated in 2017, UK) [11].

(2) Evidence summaries were evaluated using the "Critical Appraisal for Summaries of Evidence (CASE)" tool [12].

(3) Systematic reviews were appraised using the "JBI Critical Appraisal Tool" (2017 version) [13].

(4) Expert consensus documents were assessed using the "JBI Quality Assessment Tool for Expert Opinions and Consensus" (2016 version) [14].

2.6. Evidence extraction, integration, and evaluation

Two researchers with expertise in evidence-based medicine independently assessed the quality of the included literature, extracted evidence, and graded its quality. In cases of disagreement, a third field expert was consulted to resolve inconsistencies and achieve consensus. A preliminary summary of the evidence was prepared. Subsequently, an expert panel consisting of one nephrologist, two nursing specialists, and two evidence-based nursing practice experts reviewed and discussed the evidence content to finalize the draft. When conclusions

from different sources conflicted, evidence-based principles were applied, prioritizing higher-quality, authoritative, and recently published evidence.

2.7. Classification of evidence

The "JBI Evidence Pre-Grading and Recommendation Level System" (2014 edition) was used to classify the evidence into five levels (1–5). Recommendations were categorized into A-level (strong recommendation) and B-level (weak recommendation) based on the validity, feasibility, applicability, and clinical significance of the evidence [15]. Any disagreements regarding the evidence classification were resolved through group discussion.

3. Results

3.1. Basic characteristics of included literature

A total of 129 articles were retrieved. After deduplication and initial screening based on titles and abstracts, 84 articles remained. Further screening through full-text reading and quality evaluation resulted in the inclusion of nine articles: one clinical decision [16], five guidelines [17-21], one evidence summary [22], one systematic review [23], and one expert consensus [3]. The basic characteristics of the included literature are presented in **Table 1**.

Table 1. Basic characteristics of included literature (n = 9)

Literature	Publication time (year)	Country	Document type	Subject
Allon [16]	2021	America	Clinical decision-making	Overview of maintenance of arteriovenous fistula and prevention of thrombosis in hemodialysis
China Health Commission [17]	2021	China	Guide	Standard operating procedures for blood purification
Wasse et al. [18]	2020	America	Guide	Clinical nursing practice guidelines for hemodialysis patients
Lok et al. [19]	2020	Canada	Guide	Clinical practice guidelines: Vascular access
Gallieni et al. [20]	2019	Italy	Guide	Perioperative and postoperative care of arteriovenous fistula and graft in adult hemodialysis patients
Schmidli et al. [21]	2018	Switzerland	Guide	Clinical practice guidelines: Vascular access
Du et al. [22]	2022	China	Evidence summary	Summary of the best evidence for prolonging the service life of autogenous arteriovenous fistula
Wong et al. [23]	2014	Canada	Systematic review	Systematic review of the application of buttonhole and rope ladder methods in arteriovenous fistula
Blood Access Working Group, Branch of Blood Purification Center Management, China [3]	2019	China	Expert consensus	Expert consensus on vascular access for hemodialysis in China

3.2. Results of literature quality evaluation

The included literature comprised one clinical decision [16] from UpToDate, which was evaluated with all items rated as "yes." Five guidelines [17-21] were included, all demonstrating overall high quality. One evidence summary [22] was

evaluated, with all items rated as "yes" and deemed to be of high quality. A systematic review [23] was similarly rated as "yes" for all evaluation criteria. Finally, one expert consensus article [3] was included, with all items rated as "yes."

3.3. Summary of evidence

A total of 18 pieces of evidence were summarized from the included literature and categorized into six key areas: team building and personnel training, timing of initial puncture, pre-puncture evaluation, puncture methods, post-puncture pressure management, and management of puncture-related complications. Evidence was classified according to the "JBI Evidence Grading Standard" [15] into levels 1–5, while guidelines retained the evidence grading system used in their original texts. **Table 2** provides a detailed summary of the evidence.

Table 2. Summary of evidence for new fistula puncture management

Category of evidence	Content of evidence	Level of evidence
Team building and personnel training	(1) It is recommended that dialysis centers establish multidisciplinary teams for vascular access management [3,19].	2a
	(2) It is recommended to appoint one or more vascular access nurses to improve clinical services for patients [17-19,21,22].	2a
	(3) Structured training and supervision should be provided to dialysis nurses based on the characteristics of new fistulas, with regular updates to maintain their puncture skills [19].	5b
First puncture timing	(4) It is recommended to initiate puncture 8–12 weeks after AVF creation. In special cases, puncture may begin at least one month after AVF maturation [3,22].	5b
	(5) In exceptional circumstances, such as avoiding the use of catheters, puncture may be performed 2–3 weeks post-surgery [3,17,18,20].	5b
Pre-puncture evaluation	(6) Imaging examinations should confirm AVF maturity, including natural blood flow ≥ 500 mL/min, vein diameter ≥ 5 mm, and depth from the skin < 6 mm [3,23].	5b
	(7) Prior to puncture, assess the limb's skin color, temperature, swelling, pain, and integrity. Vascular vibration, elasticity, and tension should also be evaluated, including the arm-lift test and pulsation enhancement test [3,17].	5b
Puncture method	(8) Initial AVF punctures should be performed by experienced and skilled nurses to avoid complications, such as hematoma [17,19].	5b
	(9) Real-time ultrasound-guided puncture is recommended for initial AVF use or in challenging cases [15,21].	5b
	(10) The use of 17–18G needles is recommended during the initial stages of AVF use [18,21].	1b
	(11) Wet needle puncture is recommended [3,16,19].	5b
	(12) During puncture, the needle bevel should face upward, and arterial punctures should be performed in a centripetal direction. The puncture point should be at least 3 cm from the anastomosis site, with a distance of more than 5 cm between arterial and venous puncture points [3,17].	5b
	(13) In cases requiring early puncture, alternative veins should be selected as the venous circuit whenever possible [3,17,20].	3b
	(14) Lower blood flow (180–200 mL/min) is recommended during the initial stages of AVF use [3,22,23].	5b
Post-puncture pressure management	(15) After dialysis, pressure should be applied immediately after complete needle removal, with compression maintained for 15–30 minutes. Pressure should be sufficient to stop bleeding while ensuring vascular vibration remains detectable [3,17].	5b
	(16) Finger pressure is recommended over pressure bands during the early stages of AVF use [3,17].	5b

Table 1 (Continued)

Category of evidence	Content of evidence	Level of evidence
Management of puncture complications	(17) For vascular infiltration, ice should be applied for at least 10 minutes. For moderate infiltration, the needle should be removed immediately, and manual compression applied. In cases of significant infiltration, the need for a second puncture should be assessed. If required, puncture should occur proximal to the infiltration site. If puncture is not possible, manual compression and ice application for 30 minutes are recommended, and re-puncture should be avoided at the infiltrated site [19].	5b
	(18) In cases of hematoma, the site should be closely evaluated for swelling range, proximal and distal blood flow, and related collateral circulation. Intermittent cold compresses are recommended for the first 24 hours. If bleeding has ceased, hot compresses, physical therapy, or anti-swelling ointments may be applied after 24 hours to reduce swelling [17].	5b

4. Discussion

4.1. Establish a multidisciplinary team for vascular access management and prioritize the management of new fistulas

A professional multidisciplinary team for vascular access management serves as a critical foundation for improving the success rate of punctures during the initiation stage of new fistulas and plays a decisive role in implementing scientific puncture management. **Evidence 1–3** highlights the training needs for multidisciplinary teams and personnel involved in vascular access management. The establishment of such teams should include specialized physicians, ultrasound specialists, nurses with advanced puncture skills, nurses trained in ultrasound-guided puncture, and other relevant professionals. These team members participate in evaluating, monitoring, and performing punctures on new and complex fistulas, as well as managing vascular access complications. This integrated approach ensures that vascular access management, particularly during the activation phase of new fistulas, is both scientific and effective.

Vascular access nurses play a crucial role in managing new fistula punctures and should be responsible for evaluations, puncture execution, post-puncture assessments, and puncture planning. To ensure competence, a standardized selection mechanism for vascular access nurses should be established, and regular systematic training and assessments should be conducted.

4.2. Accurate timing of the first puncture for new fistulas

The success of AVF puncture during the initiation stage largely depends on a comprehensive assessment of fistula maturity. **Evidence 4–5** outlines the appropriate timing for the first puncture following AVF creation surgery. Timing is a critical factor influencing the long-term prognosis of the fistula. **Evidence 4** recommends initiating puncture 8–12 weeks post-surgery, while puncture within the first month is generally discouraged. In exceptional cases, such as avoiding catheterization or the use of trocar puncture, puncture may be performed 2–3 weeks after surgery.

Studies have shown that the incidence of poor AVF maturation ranges between 10% and 33% [24]. Therefore, medical staff must accurately assess AVF maturity based on established criteria to prevent puncture failures caused by immature fistulas, which could compromise the fistula's long-term viability.

4.3. Standardized evaluation process before new fistula use

Evidence 6–7 highlights the evaluation methods before the first puncture of an AVF, emphasizing the importance

of combining imaging examinations with physical assessments. Imaging can objectively determine key indicators of AVF maturity, such as natural blood flow, the inner diameter of the puncture segment, and depth beneath the skin. When used alongside AVF maturity criteria [3], imaging provides a reliable assessment of readiness for puncture.

Physical examinations, though more convenient and economical than imaging, are often underutilized in clinical practice. Key tests, such as the arm-lift test and pulse enhancement test, are sometimes overlooked despite their utility in evaluating AVF patency and blood flow. To address this, training programs should emphasize these physical examination techniques, ensuring their routine application in practice. Vascular access nurses should combine imaging results with physical assessments to provide an accurate evaluation of AVF maturity before the first puncture.

4.4. Implementation of a scientific puncture strategy during AVF activation

The experience and puncture techniques of nursing staff directly influence AVF outcomes. **Evidence 8** recommends that skilled and experienced nurses perform punctures during the AVF activation phase to minimize adverse events such as hematomas caused by puncture failures. **Evidence 9–14** provides detailed guidance on the selection of puncture needles, puncture directions, angles, and appropriate blood flow during this phase.

New fistula vessels are characterized by thin and fragile walls. During activation, the use of smaller gauge needles and lower blood flow rates can reduce wall shear stress, minimizing intimal hyperplasia and stenosis formation [25]. Abroad, dialysis trocars have been widely utilized for years, especially during the AVF activation stage, due to their effectiveness in protecting vascular integrity. However, clinical practice in China remains limited. Further research into the use of trocar punctures during AVF activation is therefore recommended.

Evidence 9 emphasizes the value of real-time ultrasound-guided punctures for first-time use or difficult cases. Compared to traditional blind punctures, ultrasound guidance allows for real-time visualization of vessel depth, diameter, and needle trajectory. Nurses can adjust the needle insertion angle and depth according to the actual vascular conditions, ensuring precise needle placement and reducing puncture complications [4]. This technique significantly improves the success rate of AVF punctures.

4.5. Management and education of puncture complications

Evidence 15–16 provides recommendations on post-puncture compression techniques, suggesting finger pressure instead of pulse pressure bands during the AVF activation stage. Operators should use their thumbs to apply pressure directly to the vascular puncture site, ensuring consistent monitoring for swelling or bleeding. Compared to pulse pressure bands, finger pressure can be adjusted in real time based on the bleeding status, thereby minimizing the applied pressure, reducing hemostasis time, and lowering the risk of complications [26].

Evidence 17–18 outlines the management strategies for hematomas in the puncture area. If vascular injury occurs, the needle should be removed immediately, and accurate manual compression combined with ice application should be performed to prevent further damage to the AVF. Nursing staff must continuously observe the puncture site for swelling, particularly when it is close to the anastomosis. Careful attention should also be paid to AVF vibration, which indicates patency. Patients should be guided on appropriate home care measures to support recovery and minimize complications.

5. Summary

This study summarizes the best available evidence for puncture management during the early initiation stage of autologous arteriovenous fistulas in hemodialysis patients, offering strong clinical guidance and significance. The nine included studies underwent rigorous quality evaluation, and the overall quality of the evidence is relatively high. However, the inclusion of evidence was limited to publicly available studies in Chinese and English, which may have led to the exclusion of high-quality research published in other languages.

Furthermore, as part of the evidence originates from international sources, medical staff should adapt and develop localized, patient-specific intervention plans when implementing the findings. Future clinical applications of this evidence will be essential to validate its efficacy and further enrich research in this field.

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Disclosure statement

The authors declare no conflict of interest.

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