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# Analysis of factors associated with repeated needling of arteriovenous fistulas in haemodialysis patients

Elena Guerrero-Rodríguez[1], Iris Rubio-Segovia[1], Ignacio Escanes-Martínez[1], Julia Audije-Gil[2], David Hernán-Gascueña[2], María Dolores Arenas-Jiménez[2]

[1] Fundación Renal Española, Centro Los Llanos II, Getafe, Madrid, Spain

[2] Fundación Renal Española, Madrid, Spain

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**Corresponding author:**
Elena Guerrero Rodríguez
eguerrero@fundacionrenal.es

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## ABSTRACT

**Introduction:** Identifying variables associated with difficult fistula cannulation may help prevent complications.

**Objective:** To determine the incidence of repeated cannulations and analyse the factors influencing successful cannulation.

**Material and Method:** We conducted a descriptive, retrospective, cross-sectional study in 2024. The variables analysed included number of re-cannulations, type and location of fistula, needle position, duration of use, and nurses' length of professional experience. Student's t test, Mann–Whitney U test, and chi-square test were used.

**Results:** A total of 81,968 sessions from 1,167 patients were included; 69% were men and 31% women, with a mean age of 66.4±14.8 years and a mean BMI of 26.4±5.4. Autologous arteriovenous fistulas accounted for 92% and prosthetic fistulas for 8%. Fistula types were humerocephalic (45.8%), radiocephalic (40.5%), humerobasilic (7.6%), and others (6.1%); 80% were in the right arm and 20% in the left arm. Needles were inserted anterogradely in 99% of cases. Mean nursing experience was 6.7 years. Repeated cannulations occurred in 1% of sessions; 83.6% involved a single additional puncture, and 71% affected the venous needle. Factors associated with a higher number of repeated cannulations included prosthetic fistulas (1.8 *vs* 0.9, $p<0.001$); fistula type—humerohumeral (2%), humeroaxillary (2%), humerobasilic (1.3%), radiocephalic (1.1%), and humerocephalic (0.7%) ($p<0.001$); retrograde cannulation (2.2% *vs* 1%, $p=0.002$); shorter duration of use (median 29 months, $p<0.001$); and greater nursing seniority (median, 3.3 years, $p=0.003$).

**Conclusions:** The incidence of repeated cannulations was low. Prosthetic, deep, and recently created fistulas, as well as retrograde cannulation, were associated with a higher number of additional punctures. Contrary to expectations, nurses with greater professional experience recorded a higher number of re-cannulations.

**Keywords:** haemodialysis; arteriovenous fistula; cannulation; complications.

## RESUMEN

**Análisis de los factores asociados a la punción repetida de las fístulas arteriovenosas en pacientes en hemodiálisis**

**Introducción:** La identificación de las variables asociadas a un abordaje difícil de la fístula puede contribuir a prevenir complicaciones.

**Objetivo:** Determinar la incidencia de punciones repetidas y analizar los factores que influyen en una punción exitosa.

**Material y Método:** Estudio descriptivo, retrospectivo de corte transversal, realizado durante 2024. Variables analizadas: número repunciones, tipo y localización de fístula, posición de

agujas, tiempo de uso y antigüedad del enfermero. Se empleó t de Student, U de Mann-Whitney y chi cuadrado.

**Resultados:** Incluidas 81.968 sesiones de 1.167 pacientes, 69% varones y 31% mujeres, edad media 66,4±14,8 años e IMC 25,7(22,6-29,3). El 92% FAV autóloga y 8% protésica. Tipo de fístula: Humero-cefálica 45,8%, radio-cefálica 40,5%, humero-basílica 7,6% y otros 6,1%; 80% brazo derecho y 20% izquierdo. El 99% agujas canalizadas anterógradas. Antigüedad de los enfermeros mediana de 3,3 (RIQ 1,5-5,9) años. Incidencia de punciones repetidas en el 1% de las sesiones; 83,6% una única punción extra y el 70,3% aguja venosa. Variables asociadas a más punciones repetidas: fístula protésica (1,8 *vs* 0,9, $p<0{,}001$); tipo de fístula: Humero-humeral 2%, humero-axilar 2%, humero basílica 1,3%, radio-cefálica 1,1% y Humero-cefálica 0,7% ($p<0{,}001$); canulación retrógrada (2,2% *vs* 1%, $p=0{,}002$; menor tiempo de uso (mediana 29 meses, $p<0{,}001$) y mayor antigüedad del enfermero (mediana 3,3 años, $p=0{,}003$).

**Conclusión:** La incidencia de punciones repetidas fue baja. Las fístulas protésicas, profundas y de reciente creación, así como la punción retrógrada, se asociaron a mayor número de punciones adicionales. Pese a lo esperado, los enfermeros con mayor antigüedad registraron mayor número de repunciones.

**Palabras clave:** hemodiálisis; fístula arteriovenosa; punciones; complicaciones

## INTRODUCTION

Haemodialysis (HD) is the most widely used renal replacement therapy worldwide. In Spain, approximately 78% of patients with chronic kidney disease undergoing dialysis receive this treatment, and in Europe more than 80,000 people depend on it for survival[1,2].

The efficacy of haemodialysis directly influences patients' quality of life and morbidity and mortality, and this effectiveness is largely determined by the type and functionality of the vascular access used[3,4].

Among the different available accesses, the arteriovenous fistula (AVF) is considered the access of first choice due to its durability and lower rate of infectious complications[3-8]. Nevertheless, its correct management represents a technical challenge that requires a high level of competence from nursing staff and constitutes one of the main sources of concern for both professionals and patients dialysing through it.

Factors that may hinder AVF cannulation include the patient's own anatomical characteristics (such as the quality of the available arterial and venous bed) and functional aspects of the fistula *per se:*

- Insufficient maturation may increase the incidence of cannulation-related complications (such as haematomas or thrombosis) and compromise access survival[4].
- Anatomical location is also crucial, as puncture sites must be accessible; in some cases, surgical techniques are required to facilitate cannulation (vein superficialisation)[9].
- The AVF must tolerate repeated puncture, which is particularly challenging in tortuous veins or vessels with fragile walls.

Furthermore, other determining factors are not patient-related but instead depend on the nurse performing the cannulation, such as experience with this type of access, ultrasound skills for ultrasound-guided cannulation, and specific training in vascular access[4-10].

Inadequate cannulation may result in minor complications, such as extravasation or haematoma formation, but can also lead to more serious fistula-related events, including infection, stenosis, aneurysm or pseudoaneurysm formation, and even access thrombosis. These complications compromise fistula viability and often require the placement of a central venous catheter as an alternative[4], which increases patient morbidity and mortality, healthcare costs, and the workload for nursing staff.

This procedure also has psychological repercussions. Several studies have shown that pain associated with cannulation and its potential complications are related to increased levels of anxiety and fear in patients[8]. This situation not only affects the fistula bearer but also negatively influences the therapeutic relationship between patient and nurse, weakening trust and worsening the perceived quality of care received[8,11-13]. Furthermore, patients who experience multiple cannulation attempts or fistula-related adverse events report lower overall satisfaction with their treatment[14].

Currently, few studies have examined in depth the adverse effects associated with AVF cannulation[10-12]. Most focus on severe complications requiring surgical intervention, while literature addressing extravasation, repeated punctures, or the need to dialyse using a single puncture or using a catheter as venous return remains scarce.

Although clinical experience allows most nephrology nurses to recognise which types of fistula tend to present greater cannulation difficulty, there are very few studies clearly defining which characteristics make an access difficult to cannulate[9-15]. Identifying in advance which fistulas are potentially challenging would allow more accurate and efficient planning of cannulation, thereby reducing the risk of complications related to failed attempts.

The aim of this study was to analyse the prevalence of repeated punctures in patients undergoing HD via an AVF, and to identify the factors influencing correct cannulation, with the ultimate goal of improving patients' overall wellbeing.

## MATERIAL AND METHOD

### Study Design and Setting

We conducted a multicentre, descriptive, retrospective, cross-sectional study. HD sessions performed between January 2nd and December 31st 2024 were analysed in 18 dialysis units of the Spanish Renal Foundation, including both hospital-based and outpatient centres (Spanish Renal Foundation, Centro Los Llanos II, Madrid, Spain; Spanish Renal Foundation, Madrid, Spain).

### Population and Sample

All sessions from patients dialysed through an AVF were included.

### Study Variables

Demographic variables included age, sex and nationality. Clinical variables comprised: need for additional puncture, number of repeated punctures, type of fistula used for dialysis, anatomical location of the fistula, needle direction (retrograde or antegrade), fistula age (in months), and the nurse's professional experience (in years).

### Data Collection Methods

Data were obtained from the electronic medical record system Nefrosoft version 7.3.1. The nurse responsible for each session manually recorded needle position and whether additional punctures were required, including the number of attempts.

### Statistical Analysis

Categorical variables were expressed as absolute frequencies and percentages. Continuous variables were presented as mean and standard deviation. Distribution normality was assessed using the Kolmogorov–Smirnov test and visual inspection of histograms. For normally distributed variables, Student's t-test for independent samples was used, reporting mean and standard deviation. For non-normally distributed variables, the Mann–Whitney *U* test was applied, with results expressed as median and 25th and 75th percentiles. Categorical variables were compared using the chi-square test. Statistical analysis was performed with IBM SPSS Statistics version 29.0.1.0, with statistical significance set at p≤0.05.

## RESULTS

A total of 81,968 haemodialysis sessions corresponding to 1,167 patients were analysed. The mean age was 66.4±14.8 years and the median body mass index (BMI) was 25.7 (22.6–29.3) kg/m². 68.9% (n=56,480) of patients were male and 31.1% (n=25,488) female. 74.8% (n=28,042) were of Spanish nationality and 25.2% (n=9,457) were immigrants.

The vascular access used for dialysis was predominantly native arteriovenous fistulae (AVF) in 92.1% (n=75,464) of cases, compared with 7.9% (n=6,504) prosthetic AVFs. The anatomical distribution of fistulae is shown in **figure 1.**

Regarding the limb bearing the AVF, 79.9% (n=31,149) were located in the right arm and 20.1% (n=7,830) in the left arm. Concerning the direction of needle insertion, in 99.1% (n=76,609) of cases the arterial needle was inserted anterogradely, and in 0.9% (n=726) retrogradely. The median length of experience of the nurses performing the cannulations in the centres participating in the Spanish Renal Foundation was 3.3 years (IQR, 1.5–5.9).

Analysis of additional cannulations showed that in 818 of the 81,968 sessions at least one extra puncture was required, representing 0.99% of all sessions. Considering that two punctures are performed per fistula in each HD session, the rate of repeated punctures relative to the total number of punctures was 0.49%. In 70.3% (n=575) of cases, the additional puncture involved the venous needle, while in 29.7% (n=243) it was required for the arterial needle. Regarding the number of repeated punctures, 83.6% (n=684) of sessions required one additional puncture, 14.4% (n=118) two punctures, and 1.9% (n=16) more than two.

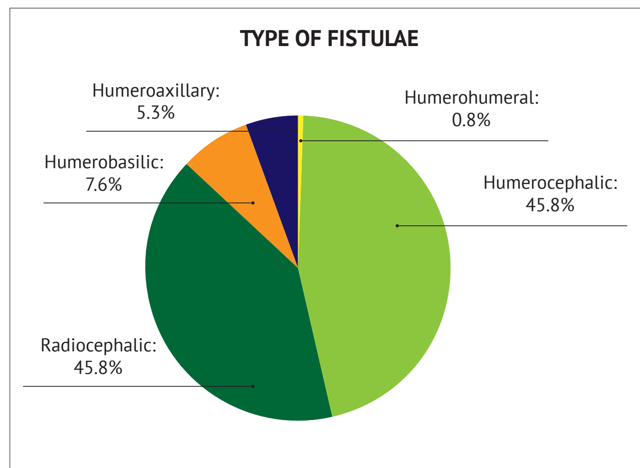


**Figure 1.** Percentage distribution of fistulae by anatomical location.

Several factors were significantly associated with the need for repeated punctures. Prosthetic AVFs required more additional punctures than native AVFs (0.9% [n=701] *vs* 1.8% [n=117]; p<0.001). Humerohumeral fistulae (2%, n=13), humeraxillary (2%, n=85) and humerobasilic (1.3%, n=78) fistulae required more additional punctures than radiocephalic (1.1%, n=355) and humerorcephalic (0.7%, n=272) fistulae (p<0.001). Needle orientation was also determinant: anterograde cannulation required fewer additional punctures than retrograde cannulation (1% [n=776] *vs* 2.2% [n=16]; p=0.002).

The duration of fistula use was longer in fistulae that did not require additional punctures compared with those that did (median 29 months [12–52] *vs* 11 months [4–31]; p<0.001).

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Similarly, the length of nursing experience was lower in fistulae that did not require additional punctures (median 3.3 years [1.5–5.9] *vs* 4.3 years [1.7–7.7]; p=0.003).

No significant differences were observed according to sex, age, BMI, nationality, or limb used for fistula creation, as shown in **table 1.**

## DISCUSSION

One of the main challenges in nephrology nursing practice is maintaining vascular access in optimal condition, as this is essential to ensure safe and effective dialysis.[13] This study analysed over 80,000 HD sessions performed through AVFs and aimed to provide conclusive data to facilitate daily nephrology nursing practice and improve the quality of vascular access management.

The incidence rate of additional punctures was <1% of all analysed sessions. Although this may be considered a positive finding and a reflection of good nursing practice, its clinical importance should not be underestimated. Direct comparison with previous studies is difficult, as the literature generally reports vascular access complications without specifying the proportion of repeated punctures per session. Van Loon et al. (2009) observed that 37% of patients with native fistulae and 19% with prosthetic fistulae required more than ten additional punctures over nearly two years of follow-up[16], although their data were expressed per patient rather than per session. Other studies focusing on access-related adverse events (extravasation, perineedle bleeding, infections, accidental needle dislodgement, etc.) do not specifically report repeated punctures[10-15,] limiting direct comparison.

With regard to the factors significantly associated with the need for additional punctures, our findings indicate that prosthetic AVFs require a higher number of additional punctures compared with native AVFs. These differences, which were statistically significant in the present study, have also been reported in previous literature[7-17]. Those studies associate the use of prosthetic material with higher rates of thrombosis, stenosis and puncture-related complications, and indicate that this type of fistula requires a greater number of interventions to maintain patency[4]. Nevertheless, other studies, such as that of Van Loon et al. (2009), have reported a higher percentage of puncture errors in native fistulae[16]. Among the factors that may hinder cannulation in prosthetic AVFs are the greater rigidity and reduced elasticity of the graft[4]. the more limited puncture area[4]. reduced perception of thrill[9]. and the more rapid deterioration of the graft wall, which, moreover, does not regenerate[3,4].

Humerohumeral, humeroaxillary and humerobasilic fistulae required a higher number of additional punctures, suggesting greater technical complexity. Recent literature supports this observation, indicating that deep fistulae are more difficult to cannulate than superficial ones, particularly if they have not been transposed or superficialised prior to use[9]. Furthermore, several studies report that the initial punctures of all fistulae, especially those with high intra-access flow (such as humerobasilic fistulae), carry a higher risk of extravasation, which may necessitate more additional punctures[17]. From an anatomical perspective and based on clinical experience, it is reasonable to assume that greater depth impairs both palpation and vascular access. Accordingly, several studies recommend the use of ultrasound-guided cannulationfor this type of access to minimise extravasation and reduce the need for additional punctures[6].

The need for additional punctures was lower in fistulae cannulated with anterograde needle orientation compared with those cannulated retrogradely. According to the Spanish Clinical Guidelines for Vascular Access in Haemodialysis[4]. there is consensus that the venous needle should always be oriented in the direction of blood flow (anterograde). However, some controversy remains regarding the optimal orientation of the arterial needle, which may be positioned either anterogradely or retrogradely. Several studies have indicated that the

**Table 1.** Distribution of sessions according to the need for additional punctures.

| Characteristic/Parameter | | Additional Puncture | | Total |
|---|---|---|---|---|
| | | No | Yes | |
| Sex | Male<br>Female | 55,901 (99.0%)<br>25,249 (99.1%) | 579 (1.0%)<br>239 (0.9%) | 0.244 |
| Nationality | Spanish<br>Immigrant | 27,708 (98.8%)<br>9,356 (98.9%) | 334 (1.2%)<br>101 (1.1%) | 0.334 |
| Access material | Native<br>Prosthetic | 74,763 (99.1%)<br>6,387 (98.2%) | 701 (0.9%)<br>117 (1.8%) | **0.000** |
| Type of fistula | Humerobasilic<br>Humeroce-phalic<br>Humeroaxillary<br>Radiocephalic<br>Humerohumeral | 6,085 (98.7%)<br>36,952 (99.3%)<br>4,244 (98.0%)<br>32.493 (98.9%)<br>628 (98%) | 78 (1.3%)<br>272 (0.7%)<br>85 (2.0%)<br>355 (1.1%)<br>13 (2%) | **0.000** |
| Location | Left<br>Right | 7,747 (98.9%)<br>30,865 (99.1%) | 83 (1.1%)<br>284 (0.9%) | 0.125 |
| Needle orienta-tion | Anterograde<br>Retrograde | 75,833 (99.0%)<br>710 (97.8%) | 776 (1.0%)<br>16 (2.2%) | **0.002** |
| Age (years)<br>BMI (kg/m²) | | 66.4±14.8<br>26.4±5.4 | 66.8±14.8<br>26.5±5.2 | 0.252<br>0.392 |
| Nursing experience (years) | | 3.3 (1.5–5.9) | 4.3 (1.7–7.7) | **0.003** |
| Fistula age (months) | | 29 (12–52) | 11 (4–31) | **<0.001** |

***BMI:** Body Mass Index.

direction of arterial needle insertion does not significantly influence dialysis efficacy[4,16], although anterograde arterial puncture has been associated with improved AVF survival[4]. With respect to the effect of needle orientation on the need for additional punctures, the present study shows that retrograde orientation is associated with a higher frequency of repeated punctures. This finding is supported by several studies demonstrating that the anterograde technique is significantly safer and requires fewer additional punctures[5,7,18]. In contrast, only 1 study cited by Van Loon et al. (2009)[16] suggests that retrograde arterial puncture is associated with fewer cannulation-related complications. According to Parisotto et al. (2014), retrograde puncture presents greater technical difficulty due to reduced needle stability—resulting from flow turbulence—and a higher probability of acute complications such as infiltrations and haematomas[7]. Moreover, as most current nursing protocols are designed for anterograde puncture, the retrograde approach may pose additional difficulty for nursing staff because of their more limited experience with this technique.

Regarding fistula vintage, older fistulae (>29 months) were associated with fewer additional punctures. These results are consistent with previous studies, which attribute this association to the fact that longer-standing fistulae have had sufficient time to mature properly, allowing anatomical stabilisation that facilitates cannulation and reduces the risk of displacement[19].

According to the Spanish Clinical Guidelines for Vascular Access in Haemodialysis and the KDOQI guidelines, a fistula may be considered suitable for cannulation when it presents a venous diameter >5–6 mm, intra-access flow >500–600 mL/min, and depth <6 mm from the skin surface[3,4,20]. Additionally, other authors specify that the fistula should present a palpable thrill, audible bruit, adequate venous wall resistance and ease of cannulation.[21] To fulfil these criteria, it is generally recommended to wait 4–6 weeks from fistula creation before initiating use, although some authors advise extending this period to 3–4 months to ensure adequate maturation.[22] This is particularly relevant, as recently created fistulae (<6 months) show a higher risk of blood extravasation[4,17], thereby increasing the need for additional punctures. Consequently, early and appropriate vascular access planning during advanced chronic kidney disease clinics is essential.

Another important finding of this study is that, contrary to expectations, greater nursing seniority was associated with a higher number of additional punctures. This contrasts with previous studies reporting that greater nursing experience is associated with fewer complications during haemodialysis and increased patient confidence[11,16,17].

This apparent discrepancy may be explained by guideline recommendations that both initial cannulations and technically difficult punctures should be performed by the most experienced staff[3,4]. This would justify why, as observed in this study, nurses with greater experience perform more additional punctures, as they are responsible for cannulating newly created and more complex fistulae that require specialised care. Establishing nursing protocols to distribute workload according to clinical complexity would be beneficial to ensure efficient and safe patient care.

Among the main limitations of this study, it should be noted that, due to its retrospective design, the analysed data depend on the accurate completion of clinical records, which may affect the reliability of certain variables. Likewise, some comorbidities that could influence correct fistula cannulation (such as diabetes mellitus, peripheral vascular disease, etc.) were not considered.

With regard to nursing staff, neither specific training in vascular access nor professional experience in other institutions was evaluated.

Finally, the analysis was performed on the basis of the number of dialysis sessions rather than individual patients. This may introduce bias if some patients with difficult-to-manage access contributed a larger number of sessions, thereby influencing the overall results.

It is hoped that the findings of this study will provide a foundation for future research aimed at optimising treatment planning and the management of vascular access in haemodialysis patients, thereby helping to reduce complications and improve quality of life.

In light of these results, we conclude that the rate of repeated punctures in the analysed sessions is low, reflecting appropriate performance by nursing staff.

The characteristics of the vascular access are decisive in the development of puncture-related complications. Prosthetic fistulae, deep anatomical access locations (such as humeroaxillary or humerohumeral), and retrograde puncture are significantly associated with a higher probability of requiring additional punctures. In addition, older fistulae show a lower likelihood of extravasation.

A particularly interesting finding of this study is that greater nursing seniority is associated with more additional punctures, which may be explained by the fact that more experienced staff undertake the most complex cases and the initial cannulations.

The results reinforce the importance of considering both vascular access characteristics and staff experience when planning the cannulation approach in patients undergoing haemodialysis via an arteriovenous fistula.

**Declaration of generative Artificial intelligence use.** "During the preparation of this work, the authors used ChatGPT to improve the clarity of language. After using this tool, the authors reviewed and edited the content as necessary and assume full responsibility for the content of the publication".

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## Conflicts of interest

None declared.

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