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Influence of sex on vascular access outcomes for haemodialysis: a systematic review

Nuria Carrasco-Carmona[1], Marta Díaz-Onieva[1], María Dolores Hens-Rey[1], Rodolfo Crespo-Montero[1,2,3].

[1] Department of Nursing. Faculty of Medicine and Nursing, Universidad de Córdoba, Spain
[2] Nephrology Service, Hospital Universitario Reina Sofía de Córdoba, Spain
[3] Instituto Maimónides de Investigación Biomédica de Córdoba, Spain

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Corresponding author:
Nuria Carrasco Carmona
nuria.ccarmona@gmail.com

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ABSTRACT

Introduction: Arteriovenous fistula remains the most effective access for haemodialysis, but women are less likely to receive it than men. The reasons are not entirely clear. Likewise, women have a higher risk of mortality associated with greater use of central venous catheters, leading to gender inequalities in outcomes.

Objectives: To understand and synthesise existing scientific evidence on the influence of sex on vascular access outcomes for haemodialysis.

Methodology: A systematic review was conducted following the PRISMA statement, with articles extracted from the PubMed and Scopus databases (2019–2024). The search terms used were: "female", "gender", "sex", "haemodialysis", and "vascular access".

Results: A total of 14 articles were included, 13 of which correspond to observational studies, whilst 1 is a bioinformatic study. The synthesis of the reviewed literature reveals physiological (immunological, genetic, venous diameter, pregnancy) and external factors (pre- and post-dialysis care).

Conclusions: The difficulties women face in achieving successful vascular access through an arteriovenous fistula are not only due to physiological factors but also to an interaction between internal and external factors, such as clinical practices. Immunological, hormonal, and genetic mechanisms that can hinder fistula maturation have been identified. Furthermore, inequalities in medical care, such as greater dependence on catheters and less effective pre-dialysis care, contribute to worse outcomes for women.

Keywords: vascular access; haemodialysis; sex; gender; arteriovenous fistula.

RESUMEN

Influencia del sexo en los resultados del acceso vascular para hemodiálisis. Una revisión sietemática

Introducción: La fístula arteriovenosa sigue siendo el acceso más eficaz para la hemodiálisis, pero las mujeres tienen menos probabilidades de recibirla que los hombres. Las razones no están completamente claras. Asimismo, las mujeres presentan un mayor riesgo de mortalidad asociada al mayor uso del catéter venoso central, determinando desigualdades de género en los resultados.

Objetivos: Conocer y sintetizar la evidencia científica existente sobre la influencia del sexo en los resultados del acceso vascular para hemodiálisis.

Metodología: se realizó una revisión sistemática siguiendo la declaración PRISMA, con artículos extraídos de las bases de datos PubMed y Scopus (2019–2024). Para llevar a cabo la búsqueda se utilizaron los términos: "female", "gender" "sex", "hemodialysis" y "vascular access".

Resultados: se han incluido 14 artículos, 13 de los mismos corresponden a estudios observacionales, mientras que 1 es un estudio bioinformático. De la síntesis de la literatura revisada aparecen factores fisiológicos (inmunológicos, genéticos, diámetro venoso, embarazo) y factores externos (atención prediálisis y postdiálisis).

Conclusiones: las dificultades que encuentran las mujeres para lograr un acceso vascular exitoso mediante una fístula arteriovenosa no solo se deben a factores fisiológicos, sino a una interacción entre y factores externos, como las prácticas clínicas. Se han identificado mecanismos inmunológicos, hormonales y genéticos que pueden dificultar la maduración de la fístula. Además, las desigualdades en la atención médica, como la mayor dependencia de catéteres y la menor eficacia de la atención prediálisis, contribuyen a peores resultados para las mujeres.

Palabras clave: acceso vascular; hemodiálisis; sexo; género; fístula arteriovenosa.

INTRODUCTION

Chronic Kidney Disease (CKD) represents one of the main emerging threats to global public health, due to its progressive nature, asymptomatic presentation in early stages, and high socio-health care burden. This pathology has been recognised as a "silent epidemic" due to its increasing prevalence and the low perception of risk by both patients and non-specialist health care professionals[1].

In recent decades, the incidence of CKD has steadily increased in numerous countries, including Spain. According to data from the Spanish Registry of Kidney Patients (ONT/SEN), the rate of patients with CKD undergoing renal replacement therapy (RRT) rose from 121.1 people per million population (pmp) in 2010 to 141.4 pmp in 2020, representing an 11.6% increase[2].

In the terminal phase of CKD, RRT becomes essential for patient survival, with haemodialysis (HD) being the most frequently used therapeutic modality, ahead of peritoneal dialysis and kidney transplantation[3]. In Spain, 39.4% of patients on RRT receive HD as their primary treatment[4]. This procedure requires effective and safe vascular access, usually via a native arteriovenous fistula (NAVF), prosthetic arteriovenous fistula (PAVF), or central venous catheter (CVC)[5,6].

The NAVF is considered the vascular access of choice due to its lower rate of infectious complications, greater durability, and better overall clinical outcomes[7]. Nevertheless, the use of CVC persists as a frequent option, especially in patients with comorbidities, lack of nephrological preparation, or in urgent clinical situations, despite being associated with lower survival, less dialytic efficacy, and a higher risk of bloodstream infections[8].

Various studies have shown that the presence of a functional NAVF is directly related to greater survival for HD patients. Vs CVCs, AVFs confer a 52% reduction in the risk of mortality during the first year of HD, as well as a significant decrease in bacteraemia rates, which are up to 20 times higher with CVCs vs NAVF[8,9]. Furthermore, the initial use of CVC has been identified as an independent risk factor for mortality in HD patients[10].

The maturation and functionality of the NAVF are determined by multiple factors, both clinical, anatomical, and technical. Among the most relevant are advanced age, obesity, female sex, diabetes mellitus, cardiovascular diseases, blood vessel diameter, and surgical expertise in fistula creation[7,11].

In this context, notable sex differences have been identified in the vascular access used. Women are less likely to receive an NAVF and have a higher prevalence of CVC as primary access. In Spain, 20.8% of women on HD use CVC vs 10.8% of men, which highlights a significant care gap[12].

Although this difference has traditionally been attributed to the supposedly lower quality of venous capital in women, ultrasound studies have not demonstrated significant anatomical differences between sexes. However, some research has described poorer maturation and patency rates in female AVFs, which could influence clinical decision-making and favour the preferential use of CVC in this population[13].

On the other hand, analyses adjusted for mortality also reflect a higher rate of adverse events associated with CVC use in women vs men, highlighting an inequity in vascular access management that could contribute to poorer health outcomes in the female population[14].

Within this framework, the main objective of the present work has been to identify and synthesise the existing scientific evidence on the influence of sex on vascular access outcomes for haemodialysis. Secondary objectives included:

- Identifying the physiological factors linked to AVF failure in women.
- Exploring structural inequalities in access to vascular surgery and analysing the clinical implications of prolonged CVC exposure in this population.

METHODOLOGY

Design

We conducted a systematic review based on scientific evidence from previous studies, following the guidelines established by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement[15].

Furthermore, following the PICO model, we established the following question: "Does sex influence the use of vascular access in patients undergoing HD?" According to this model, we established:

- **P (Population):** Women on HD.
- **I (Intervention):** Existing differences between sexes.
- **C (Comparison):** Men on HD.
- **O (Outcomes):** Comparison between vascular access outcomes.
- **S (Studies):** Observational.

Search Strategy

The bibliographic search was conducted across the Pubmed and Scopus databases to select the most up-to-date information available. Data collection took place from September through December 2024.

The search method consisted of using keywords according to MeSH terminology: "female", "gender", and "sex", terms linked by "OR"; together with the terms "haemodialysis", "vascular access"; linked by the Boolean term "AND".

Eligibility Criteria

Inclusion Criteria

- Articles in English and Spanish.
- Full-text articles.
- Articles published between 2019 and 2024.
- Original articles addressing sex differences in HD vascular access.

Exclusion Criteria

- Literature reviews.
- Studies not including women.

Article Quality Assessment

The quality of the selected articles was assessed according to the checklists defined by STROBE (Strengthening the Reporting of Observational Studies in Epidemiology)[16], intended for observational studies.

Data Extraction

The information collected includes authors, year and country of publication, study design, sample used, summary of key results obtained, and quality of evidence of the selected articles. A thematic-categorical approach was used due to the disparity of variables and methodologies evaluated in the selected studies.

Synthesis of Results

For the synthesis of information, a qualitative analysis was employed, which allowed for the clear and structured organisation and interpretation of data, thus responding to the objectives proposed in this study.

RESULTS

Search Results

The search strategy identified a total of 2103 publications. After removing duplicates and applying the inclusion criteria, 618 were evaluated by title and abstract, and 42 proceeded to full-text reading. Finally, 14 publications were included in the review. This process is represented in **figure 1**, following PRISMA recommendations[15].

Characteristics of Results

Of the 14 articles chosen for this review, 13 correspond to observational studies, while 1 is a bioinformatics study. **table 1** presents the selected articles along with their most relevant data.

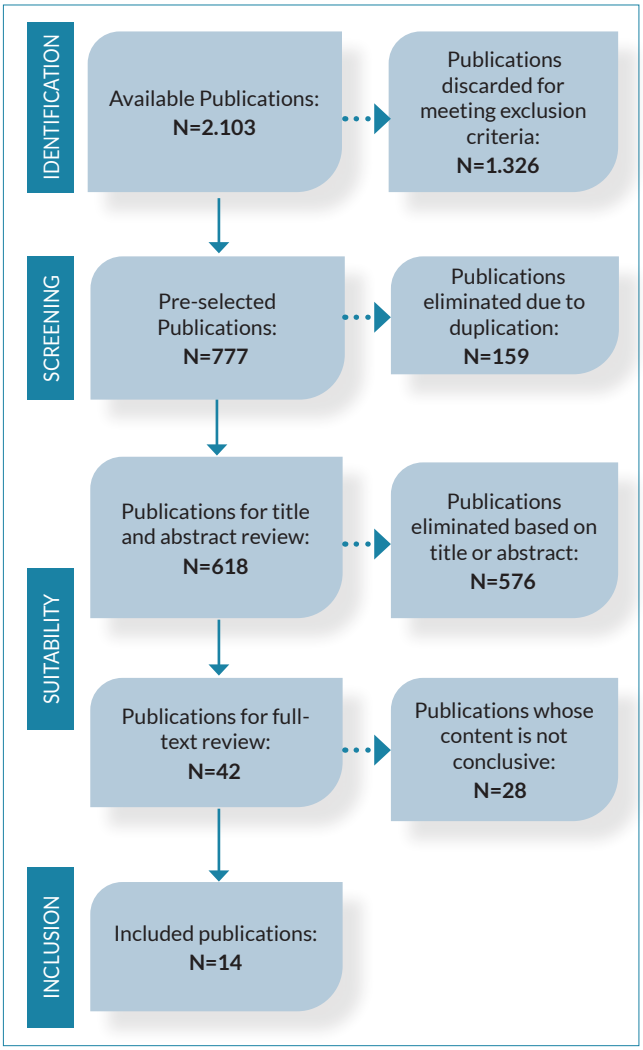

Figure 1. Flowchart of the search process.

DESCRIPTION OF RESULTS

Physiological Factors

Of the 14 articles analysed, 6 highlight the role of physiological factors as the main agents in NAVF failure among women.

Immunological Factors

On the one hand, one of the reviewed studies highlights a time difference in AVF maturation between sexes, being 82 days in men and 182 days in women. Additionally, a lower percentage of monocytes was observed in women, influencing vessel thickening and dilation during the initial fistula remodelling, with this scarcity being more pronounced in those whose fistulas failed. Among females, every 1% increase in monocytes is associated with a 1.7 increase in the odds of maturation. A possible intervention of macrophages in this process is also suspected; although no differences in total leucocytes, neutrophils, or lymphocytes

Table 1. Characteristics of the studies included in the review.

Authors and year	Study Type	Sample	Findings	Quality
Satam et al. Yale, EEUU, 2023 (17).	Retrospective observational cohort study.	56 patients - 28 women - 28 men	Women with brachiocephalic fistulas have a smaller brachial artery diameter both before and after surgery.	STROBE 18/22
Farrington et al. Alabama, EEUU, 2021 (18).	Retrospective observational cohort study.	132 patients - 66 women - 66 men	The association of elevated class II PRA antibodies with non-maturation of AVF suggests that the immune system may influence AVF maturation outcomes, especially among female patients.	STROBE 19/22
Mohazzab et al. Irán, 2022 (19).	Cross-sectional, longitudinal observational study.	466 patients - 322 women - 144 men	Female patients and hypertensive patients have a higher risk of catheter thrombosis, with diabetes being the most critical factor for infectious catheter-related dysfunction.	STROBE 17/22
Liu et al. China y Yale, EEUU, 2022 (20).	Bioinformatics study.	- 3 AVF databases.	In women with failed AVFs, key processes were identified, such as extracellular matrix organization, morphogenesis, cell proliferation, eGFR signaling regulation, and protein assembly.	Not applicable
Heindel et al. EEUU and Canadá, 2023 (21).	Retrospective longitudinal observational cohort study.	914 patients - 203 women - 711 men	Patients with radiocephalic AVFs often require intervention, on average, within the first year after creation, according to KDOQI guidelines.	STROBE 16/22
Jesudason et al. Australia, Reino Unido y Canadá, 2022 (22).	Retrospective observational cohort study.	23 women with advanced CKD during pregnancy	Catheter-related complications were minimal. With proper planning, it is possible to successfully create and use an AVF during pregnancy to minimize catheter use if preferred.	STROBE 18/22
Weigert et al. Portugal y Polonia, 2019 (23).	Retrospective observational cohort study.	1,247 patients	HD practices and treatment goals are similar for both women and men, including elderly patients.	STROBE 15/22
M. MacRae et al. Canadá, 2021 (24).	Retrospective observational cohort study.	2,375 patients - 929 women - 1,446 men	There are differences between women and men in the likelihood of receiving or successfully using an AVF. Regardless of sex, AVF use is associated with increased patient survival and fewer infections.	STROBE 18/22
Lee et al. Alabama, EEUU, 2020 (25).	Prospective observational cohort study.	9,458 patients - 4,531 women - 4,927 men	AVF may not be the best option for many older women starting HD with a CVC, and AVG should be considered as an alternative to avoid CVC dependence.	STROBE 17/22
Beaumier et al. Francia, 2022 (26).	Retrospective observational cohort study.	16,032 patients - 5,627 women - 10,405 men	The association between sex and CVC use seems to be mediated by indirect measures of the quality or timing of pre-dialysis care.	STROBE 16/22

Authors and year	Study Type	Sample	Findings	Quality
Arya et al. Atlanta, EEUU, 2020 (27).	Retrospective observational cohort study.	74,194 patients - 35,062 women - 39,132 men	Female patients spend more time with a CVC and are less likely to transition to permanent access. Minorities also spend more time with a CVC but are more likely to transition to permanent access.	STROBE 18/22
Arhuidese et al. San Diego, EEUU, 2020 (28).	Retrospective database-based observational study.	490,850 patients - 341,571 women - 456,693 men	Female gender is associated with a lower prevalence of preventive AVFs, higher use of catheters as a bridge to AVF, and lower patency *vs* men.	STROBE 18/22
Djukanović et al. Serbia, 2022 (29).	Longitudinal cohort study.	441 patients - 148 women - 293 men	Some significant gender differences were observed throughout the study, while others emerged during it, but none were due to gender disparities in the treatment applied.	STROBE 19/22
Piveteau et al. Francia, 2023 (30).	Retrospective observational cohort study.	8,856 patients - 3,188 women - 5,668 men	After adjusting for patient characteristics, women had more general practitioner visits and more frequent hospitalizations (longer than 24 hours) due to kidney conditions. In addition, hospital stays related to vascular access preparation and maintenance tended to be longer and more complex in women.	STROBE 16/22

HD; hemodialysis; **NAVF;** a native arteriovenous fistula; **PAVF;** a prosthetic arteriovenous fistula; **CVC;** a central venous catheter; **eGFR;** estimated glomerular filtration rate**; and KDOQI;** Kidney Disease Outcomes Quality Initiative.

were detected[17]. HLA antibodies, measured as PRA (Panel Reactive Antibody), can be activated after surgical vascular injury and promote immunological responses that favour hyperplasia, stenosis, or thrombosis, hindering NAVF maturation.

In cases of early NAVF failure, women present mean PRA class I and II levels 3 times higher than men. These levels are higher in patients with non-mature NAVF, highlighting a significant difference in PRA II. In particular, women with non-mature NAVF show values 6 times higher than men (18%±30% vs 3%±13%). According to Farrington C et al. (2021), PRA levels could have an indirect effect on AVF non-maturation through their pro-inflammatory action[18]. Conversely, Mohazzab A et al. (2022) suggest that both women, along with other groups such as hypertensive or obese patients, present a considerably higher risk of catheter thrombosis[19]. The difference in thrombosis rate could be affected by the duration of patient follow-up and the use of antithrombotic/thrombolytic protocols.

Genetic Factors

Another reviewed study suggests the possibility that differences between sexes lie in genetic factors. In their data analysis, 46 genes were found to show differences in their expression between failed and mature NAVF samples, regardless of sex. When performing a sex-based analysis, women with failed NAVF showed 428 genes expressed differently vs mature ones, while in men there were 174 genes. Biological processes related to gene expression and cellular macromolecule synthesis showed more activity in genes with higher expression in failed NAVF, regardless of sex[20].

In women with failed NAVF, processes related to the extracellular matrix, cell proliferation, and EGF signalling were activated, while key vascular functions were suppressed. In men, mechanisms of gene regulation, immune activation, and lipid translocation were activated, and responses to cellular stress, cytokines, and apoptosis were suppressed. Five key molecules that induce similar or opposite gene expression profiles between failed and mature AVFs were also identified, with sex-specific differences. In particular, anti-inflammatory compounds such as CGP-60474 and alvocidib reproduce patterns of expression associated with insufficiency in men, while in women they seem to counteract this insufficiency in failed AVFs. Finally, women present more unique microRNAs than men, suggesting a differential role of non-coding RNA in post-translational gene regulation in failed AVFs[20].

Venous Diameter

Regarding venous calibre, one study states that diameter does not necessarily influence NAVF maturation, although it can affect fistula velocity and flow after surgery, which impacts its maturation[17]. Similarly, neither arterial nor preoperative venous diameters show a significant relationship with non-maturation, although a 1 mm increase in venous diameter was related to a 39% reduction in the

probability of NAVF non-maturation. Average preoperative arterial diameters were similar in patients in their study whose AVF matured and those whose did not[18].

Heindel P et al. (2023) state that female patients, along with diabetics, and an intraoperative venous diameter <3.0 mm are associated with an increase in interventions, and an appropriate vessel diameter is one of the most important determinants of fistula success[21].

Pregnant Patients

The initiation of dialysis during pregnancy remains an unusual event. According to the reviewed study, 70% of evaluated women used a catheter at some point, and 70% of them had a CVC as initial vascular access. Few complications related to this were observed, with a single case of CVC infection, not requiring replacement during pregnancy. NAVF complications were mild and did not affect its use. Its presence facilitated catheter removal or avoided its use, with no differences according to access type. Most women who received an NAVF during pregnancy continued to use it postpartum[22]. Although concerns exist about aneurysms and other complications that might discourage NAVF creation during pregnancy, only one case of aneurysmal NAVF was reported, which was ligated without being used. Hormonal changes in pregnancy can induce vascular remodelling, favouring this risk. The decision must be personalised, considering the clinical context, local practices, and patient preferences. In women with advanced CKD, NAVF creation before conception or early in pregnancy can be successful, with low complication rates, and be used in later stages of pregnancy or after delivery[22].

External Factors

Of the 14 reviewed articles, 9 highlight the influence of external factors as the main causes of NAVF failure in women.

Pre-dialysis Care

Although NAVFs are considered the first-choice vascular access for HD patients, at the initiation of HD, catheter use is higher in women. According to MacRae J et al. (2021), fewer women undergo fistula creation attempts, despite receiving slightly more pre-dialysis care. This suggests that access to surgeons or willingness to perform fistula creation might vary by gender, reflecting a possible inequity in access to care. This decision by medical staff has also been recorded in other studies, attributing the cause to smaller vessel size in women[23].

After fistula creation, women often have prolonged catheter exposure and lower probabilities of successful use, possibly due to poorer maturation related to longer catheter duration and more insertion attempts. Patients with previous interventions have a higher risk of recurrence and require careful monitoring[21,24]. On the other hand, Lee T et al. (2020) report similar AVF outcomes between sexes, although women have a lower probability of creation, successful use, and unassisted maintenance, despite subsequent interventions being similar in both sexes[25]. Furthermore, Beaumier M et al. (2022) emphasised the importance of pre-dialysis care, and how its deficiency could partly explain CVC use in women. Their results demonstrate that females experience less effective prior care, presenting malnutrition and anaemia at dialysis initiation. Additionally, they suffer from late referral to nephrology and highlight the possibility that aesthetic considerations limit their options[26].

Although women receive the same number of fistula procedures as men, they are less prone to using it. While the maturation rate is similar, they have fewer creation attempts, more time with a catheter, and take longer for the fistula to mature. Men are almost three times more likely to use the fistula without a catheter, suggesting women's limited access to bailout therapies[21].

Preventive NAVF placement is less frequent in women, who also present greater use of catheters as bridging access. NAVF maturation and patency are lower in them, with no significant differences in infections justifying excisions. In a study conducted in the United States, women used CVCs for longer (245.8 vs. 200.8 days) and had longer transitions to HD, regardless of initial access. They also showed a lower probability of transitioning to NAVF and a higher probability of proximal AVF, with the latter increasing with age in both sexes. These factors, along with the delay between HD initiation with a catheter and permanent access placement, represent preventable exposure to risks, thus reducing catheter use and time is key to improving their outcomes[27,28].

According to the results of 2 of the studies, no inequalities were found between women and men regarding vascular access disparities, although there were differences in HD treatments. Similar percentages of men and women were referred late to a nephrologist, and these percentages are consistent with the proportion of patients dialysed by CVC in the first year[23,29].

NAVFs require interventions to maintain patency, while PAVFs need healing time before cannulation; if this is not achieved, CVC use is prolonged, increasing complications. The USRDS (2017) report indicates that less than 20% of patients use AVFs at dialysis initiation, with a 15% gender gap in favour of men after one year. Lee T et al. (2020) report higher AVF abandonment in women after successful use, suggesting lower effectiveness of interventions to maintain their patency. Furthermore, in women, PAVF outcomes were equal to or better than those of NAVF, with lower rates of failure and abandonment, indicating that grafts might be more beneficial in older women, reducing prolonged catheter use and its risks[25].

Post-dialysis Care

One study found few differences in post-dialysis care between sexes. Men have fewer long hospital stays and medical visits, possibly due to a higher prevalence of cardiovascular and respiratory diseases. In contrast, women present more

behavioural disorders, less autonomy, malnutrition, and inability to walk[30].

Arhuidese et al. (2020) suggest that the lower utilisation of AVF in women could explain the high rate of access-related hospitalisations, which negatively affect the patient, the system, and quality of life. More than 75% of preventive AVFs were used for HD, supporting their placement before treatment initiation. Additionally, a 36% increase in the use of catheters as a bridge to AVF was observed. On the other hand, Piveteau J et al. (2023) report longer and more complicated hospital stays for women to prepare or maintain vascular access, possibly due to smaller vascular calibre[28,30].

DISCUSSION

This review highlights the immunological factor as key in sex differences in AVF maturation. Women present fewer circulating monocytes, affecting initial vascular remodelling, while no differences were observed in leukocytes, neutrophils, or lymphocytes. Salmela B et al. (2013) link thrombophilia and female sex to a higher risk of vascular access failure due to thrombosis or stenosis[31]. Other factors such as hypertension, diabetes, age, and endothelial alterations also influence vascular response[32]. Studies identified T lymphocytes and macrophages as key regulators in maturation, with T lymphocytes modulating macrophages[33,34]. Given that women have greater innate and adaptive immune activation, this could explain the observed differences[35,36]. Furthermore, experimental studies in mice suggest that oestrogens increase immune cell recruitment, and their decrease after menopause could affect venous remodelling and NAVF patency[37-39].

HLA antibodies might be involved in AVF stenosis and thrombosis, as women exhibit higher levels of PRA I and II, suggesting a proinflammatory effect, although evidence is limited and primarily comes from transplant studies[40,41]. Furthermore, the TREM-1 receptor, present in immune cells, is associated with inflammation and could contribute to thrombosis [41].

In this review, more genes with differential expression were found in women than in men, highlighting processes such as extracellular matrix organisation and EGF signalling in failed AVFs. A 2020 study links greater venous fibrosis in women to increased TGF-ß1 and reduced BMP7, favouring smooth muscle cell and fibroblast proliferation, and reducing blood flow. Under hypoxic conditions, these cells in women show greater expression of TGF-ß1, TGF-ßR1, and Col1a, as well as greater migration, suggesting that an imbalance in TGF-ß1/BMP7 signalling could explain their greater tendency to venous stenosis and fibrosis[42]. One study identified that the genetic polymorphism (SNP) rs1492099 in the AGTR1 gene could increase the risk of NAVF dysfunction in men on HD, by affecting the function of the AGTR1 receptor, related to fibrosis and vascular changes. In women, oestrogen modulates the amount of AGTR1 receptors and the balance between AT1 and AT2, attenuating the SNP effect[43]. Additionally, microRNAs present sex-specific differential profiles, suggesting a specific regulatory mechanism in the female AVF, although no studies addressing this yet exist.

Although venous diameter does not directly influence AVF maturation, it can affect post-surgical velocity and flow, impacting the maturation process. However, anatomical differences are not associated with negative vascular outcomes or predict fistula functionality, and vessel size does not seem to depend on sex according to ultrasonographic criteria[44-46]. To optimise NAVF creation, staff and patient training is fundamental, along with the use of appropriate tools. Non-invasive preoperative evaluation helps select the ideal site, especially in women. Additionally, blood flow monitoring and postoperative surveillance improve success rates, and prior exercise can favour vascular dilation[47].

Information on pregnant women on dialysis is scarce, especially regarding vascular access, as initiating dialysis during pregnancy remains uncommon. CVCs have been shown to be safe, with few complications. Mehandru et al. (2018) described 3 cases of pregnant women with end-stage renal disease who used CVCs, rejecting fistula for aesthetic reasons and fear of procedures. There were no infections; two pregnancies went to term and one ended in spontaneous abortion[48]. Jacques L et al. (2018) reported that 1 in 4 patients with CVC in obstetric care experienced serious complications, mainly infectious, but concluded that CVCs are safe if handled carefully, with rates similar to the general population[49]. Although AVF creation is preferred, the Renal Association Guidelines offer no specific recommendations for vascular access management in pregnant women due to lack of evidence[50]. The risk of aneurysms, favoured by hormonal changes and vascular remodelling, can deter doctors from creating NAVFs in pregnant women. Although a 2012 review reported aneurysms during pregnancy, they have not been documented in pregnant AVFs. Aneurysms, present in 26% of cases, are related to puncture trauma, high flow, MMP-2, and hyperdynamic state. Rigorous follow-up is recommended, despite the lack of evidence on accelerated progression in pregnancy[51].

Women more frequently initiate dialysis with catheters and have less access to AVFs, reflecting possible inequalities in care and anatomical differences. Surgeon's willingness to create fistulas appears to be influenced by gender, reinforcing inequities in access[44], although aesthetic reasons can also favour CVC use in women[12]. Kausz AT et al. (2000) indicate that access choice depends more on the surgeon's discretion than clinical factors[52]. Furthermore, women with CKD face social and economic barriers that limit their access to treatments, especially in patriarchal societies[53].

The transition from catheter to NAVF is longer in women, with a lower probability of obtaining definitive vascular access. Only 30% of women start HD with AVF, although those who use it successfully show greater one-year

survival than men[12]. However, NAVF evolution in women is less favourable, with higher abandonment rates and more catheter-related interventions, affecting its functionality. Even so, NAVF remains a valid option in HD, although it requires multiple interventions for its maintenance[54].

In the pre-dialysis stage, inadequate care has been observed in women, with late diagnoses, poorer nutritional status, and possible aesthetic barriers. However, some studies report that men and women receive similar medical care before starting dialysis[55], and that women are more frequently referred to nephrologists[12]. Despite this, other research indicates that women have less knowledge of their disease, start HD later, and present higher mortality before treatment[56-58]. No significant differences in post-dialysis care by sex were found, although women have more vascular access-related hospitalisations. Studies conducted in the United States show a higher hospitalisation rate in women on HD, especially in young patients[59]. The lower utilisation of NAVF in women could explain this increase in complications and hospitalisations, with an estimated equality in hospitalisation rates having prevented over 30,000 admissions in five years[59]. Nevertheless, a Japanese study found no significant differences in this regard[60].

Study limitations

The main limitation of this review was the scarce number of studies with a gender/sex focus related to vascular access in HD patients. Furthermore, among the articles found, a large part did not meet the inclusion criteria, and others presented inconclusive results. Likewise, the search strategy did not cover all existing databases, which may have led to inadvertently excluding some relevant studies on the topic, by not being included in the selected databases.

Practical considerations

The findings of this review highlight the importance of considering patient sex as a potentially influential variable in vascular access outcomes for HD. In clinical practice, this could lead to a more individualised assessment of the most appropriate access type, considering possible sex-related differences.

Furthermore, health care professionals could benefit from specific training that demonstrates these differences, with the aim of optimising vascular access planning and monitoring, as well as promoting the use of NAVF in women. These considerations could help reduce fistula failure rates and complications, thereby decreasing problems associated with CVC for HD.

In view of these results, we can draw as main conclusions that the difficulties women face in achieving successful vascular access via NAVF are not explained solely by anatomical factors, but by a complex combination of physiological, social, and health care aspects. Immunological, hormonal, and genetic factors, such as lower monocyte levels and higher microRNA activity, affect AVF maturation. Hormonal changes in pregnancy can increase certain risks, although no increased risk of aneurysms or thrombosis has been associated, highlighting the need for more research.

Additionally, inequalities in medical care are determining factors: many women initiate dialysis with catheters, which increases complications and hospitalisations. This situation does not always respond to medical criteria, but to stereotypes, fears, or lack of information. Pre-dialysis care is also less effective in women, exacerbating disparities from early stages.

In conclusion, gender differences in HD access and treatment outcomes are not limited to physiological factors; they also reflect structural barriers and clinical biases that directly affect the quality of care. Promoting gender-sensitive care, improving access to appropriate information, and fostering research focused on these disparities is essential to achieve appropriate, effective, and personalised care.

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