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RESEARCH ARTICLE (ORIGINAL)

Arteriovenous fistula cannulation in hemodialysis: Constructing and validating a decision-making model

Construção e validação de um modelo de decisão para a canulação da fístula arteriovenosa em hemodiálise

Construcción y validación de un modelo de decisión para la canulación de fístulas arteriovenosas en hemodiálisis

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Abstract
Background: The arteriovenous fistula (AVF) is the preferred vascular access for hemodialysis. Four different cannulation techniques can be used: Rope Ladder (RL), Buttonhole (BH), Multiple Single cannulation Technique (MuST), or Area Puncture (AP).
Objective: To build and validate a decision-making instrument for the optimal AVF cannulation technique in hemodialysis.
Methodology: This two-stage methodological study using the *Delphi* method was conducted between October 2021 and February 2022 with 27 experts. The decision-making instrument for choosing the cannulation technique was divided into four blocks: physical assessment, ultrasound assessment, vascular access graphical representation, and observations. The content validity index ≥ 0.90 was used in the analysis.
Results: The instrument's structure obtained the unanimous agreement of the experts and an overall content validity index of 0.94.
Conclusion: The instrument under analysis proved to have the face and content validity for nursing consultations.

Keywords: nursing; arteriovenous fistula; renal dialysis; validation study

Resumo
Enquadramento: A fístula arteriovenosa é considerada como o acesso vascular de eleição para hemodiálise, a sua utilização pode ser realizada através de quatro técnicas de canulação distintas: Escada, Botoeira, MuST ou Área.
Objetivo: Construir e validar um instrumento de apoio à decisão para a técnica de canulação ideal da fístula arteriovenosa em hemodiálise.
Metodologia: Estudo metodológico em duas etapas mediante a realização da técnica de Delphi entre outubro 2021 e fevereiro de 2022 através de 27 juízes peritos. O instrumento de apoio ao modelo de decisão para a canulação foi segmentado em quatro blocos: avaliação física, avaliação ecográfica, esquema fotográfico com dermopigmentação e observações. Para análise, utilizou-se o índice de validade de conteúdo ≥ 0,90.
Resultados: Obteve-se consenso final de juízes através de uma concordância unânime na estrutura do instrumento e um índice de validade de conteúdo global de 0,94.
Conclusão: O instrumento em estudo revelou-se válido em aparência e conteúdo para aplicação em consulta de enfermagem.

Palavras-chave: enfermagem; fístula arteriovenosa; diálise renal; estudo de validação

Resumen
Marco contextual: La fístula arteriovenosa se considera el acceso vascular de preferencia para la hemodiálisis y puede realizarse mediante cuatro técnicas de canulación diferentes, escalera, ojal, MuST o área.
Objetivo: Construir y validar una herramienta de apoyo a la decisión para la técnica ideal de canulación de la fístula arteriovenosa en hemodiálisis.
Metodología: Estudio metodológico en dos etapas mediante la técnica Delphi entre octubre de 2021 y febrero de 2022 con 27 jueces expertos. El instrumento de apoyo al modelo de decisión para la canulación se segmentó en cuatro bloques: evaluación física, evaluación ecográfica, esquema fotográfico con dermopigmentación y observaciones. Para el análisis, se utilizó el índice de validez de contenido ≥ 0,90.
Resultados: El consenso final de los jueces se obtuvo mediante un acuerdo unánime sobre la estructura del instrumento y un índice de validez de contenido global de 0,94.
Conclusión: El instrumento estudiado demostró ser válido en apariencia y contenido para aplicarlo en la consulta de enfermería.

Palabras clave: enfermería; fístula arteriovenosa; diálisis renal; estudio de validación

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Introduction

Creating and maintaining functional vascular access is crucial for efficient hemodialysis (HD) therapy. The arteriovenous fistula (AVF) is widely recognized as the primary vascular access for most HD patients with chronic kidney disease (CKD) due to the lower frequency of complications and higher patency compared to other available types of vascular access (Ibeas et al., 2017; Lok et al., 2020).

The Vascular Access Clinical Practice Guidelines of the European Society for Vascular Surgery, published by Schmidli et al. (2018), define a functional AVF as one that allows successful cannulation with two needles over at least six HD sessions during 30 days, with a pump speed of at least 300 ml/min. Failing to achieve these criteria for a functionally maturated AVF for HD can imply doing more than two cannulations per HD session or possibly having to stop using due to the inability to cannulate, relying on the need of a central venous catheter (Schmidli et al., 2018).

Repeated AVF cannulation is essential for HD. However, when performed without criteria and planning in selecting the cannulation site, this systematic and traumatic procedure makes the AVF prone to complications such as hematomas, aneurysms, endothelial dysfunction, and thrombotic phenomena, which impact the morbidity and mortality of HD patients (Marticorena, 2019; Peralta et al., 2021; Pinto et al., 2021).

This study aimed to build and validate a decision-making support instrument for the optimal AVF cannulation technique in HD patients with CKD.

Background

Considered a clinically relevant aspect, the trauma associated with cannulation can be classified as mechanical or hemodynamic. Mechanical trauma occurs in each cannulation and results from physical injury to the skin and vessel walls. It is often affected by the nurses' level of proficiency in clinical practice. Hemodynamic trauma is generated, at needle insertion sites, by disturbances in blood flow caused by the blood pump speed of the HD machine (Marticorena, 2019).

The HD patient with AVF is cannulated three times a week, representing a repeated mechanical trauma of immense significance. Thus, choosing the cannulation site for every session must follow strict criteria to be defined *ad hoc*; that is, the cannulation technique must be selected for each patient considering the characteristics of their AVF (Kumbar et al., 2020; Pinto et al., 2021).

The lack of criteria and planning in selecting the cannulation site can result in the systematic puncturing of circumscribed areas of the AVF, which can lead to aneurysmal dilatations and trigger stenosis in the adjacent regions. This method, called Area Puncture (AP) cannulation, is characterized primarily by the absence of any rule for defining the needle site. The needle is placed where the puncture can be most efficiently performed with minor pain and risk of complications. However, this seemingly easy cannulation technique has the disadvantage of weakening the AVF walls, generating localized dilatation, aneurysms, and consequent fragility of the vascular walls (Parisotto et al., 2014). Pinto et al. (2021) describe that several vascular access guidelines advise against using AP cannulation due to this severe corollary. Still, Stolic et al. (2017) show that it remains an AVF cannulation technique that persists in clinical practice, with about 63% of patients with AP cannulation. Moreover, in one of the most extensive studies conducted on HD cannulation, Parisotto et al. (2014) identified AP cannulation in 65.8% of patients in a study conducted in 171 HD clinics in nine European countries, including Portugal, with 7058 participants.

A considerable number of barriers in the clinical context hinder nurses from developing their skills in cannulation, namely: i) the high workload in HD units; ii) the pressure to comply with treatment schedules; iii) the patients' refusal to be cannulated; iv) the nurses' dexterity/training in cannulation skills; v) and the training on how to safely apply and maintain cannulation techniques (Fielding et al., 2022).

Continuing nursing education in HD to prompt theoretical knowledge acquisition or developing nurses' skills, specifically in cannulating a newly created AVF, is critical and can assist in minimizing future complications. Making an informed choice of the most appropriate cannulation technique for each patient and each AVF reveals the level of proficiency of the nurse performing it. Only this way is it possible to obtain criteria for the first puncture in a single gesture, without replacement, rotation, or additional manipulation of the needle (Van Loon et al., 2009).

In 2015, the British Renal Society and the Vascular Access Society of Britain & Ireland established the MAGIC (Managing Access by Generating Improvements in Cannulation) workgroup to explore and implement improvements in vascular access care for HD across the UK. This group developed a program implementing a decision-making model based on the best available evidence. It aims to promote good practice in cannulation by implementing a decision-making algorithm to select the right cannulation technique for the right patient at the right time (British Renal Society, 2018; Fielding et al., 2022). Initially, these recommendations were intended to be based on the available best practice evidence. However, Pinto et al. (2021) demonstrate in their review that there are few recommendations with sufficient evidence support. For this reason, the MAGIC workgroup put forward recommendations based on expert consensus opinion (British Renal Society, 2018). The HD cannulation recommendations focus on patients, placing them at the center of clinical decision-making. The MAGIC workgroup recommends that patients engage in vascular access self-care as early as possible, ideally in the preparation phase before initiating HD.

Due to the need to initiate HD and, consequently, to cannulate the AVF, the MAGIC workgroup also recommends implementing an optimal cannulation scheme, achieved by applying a decision-making algorithm based

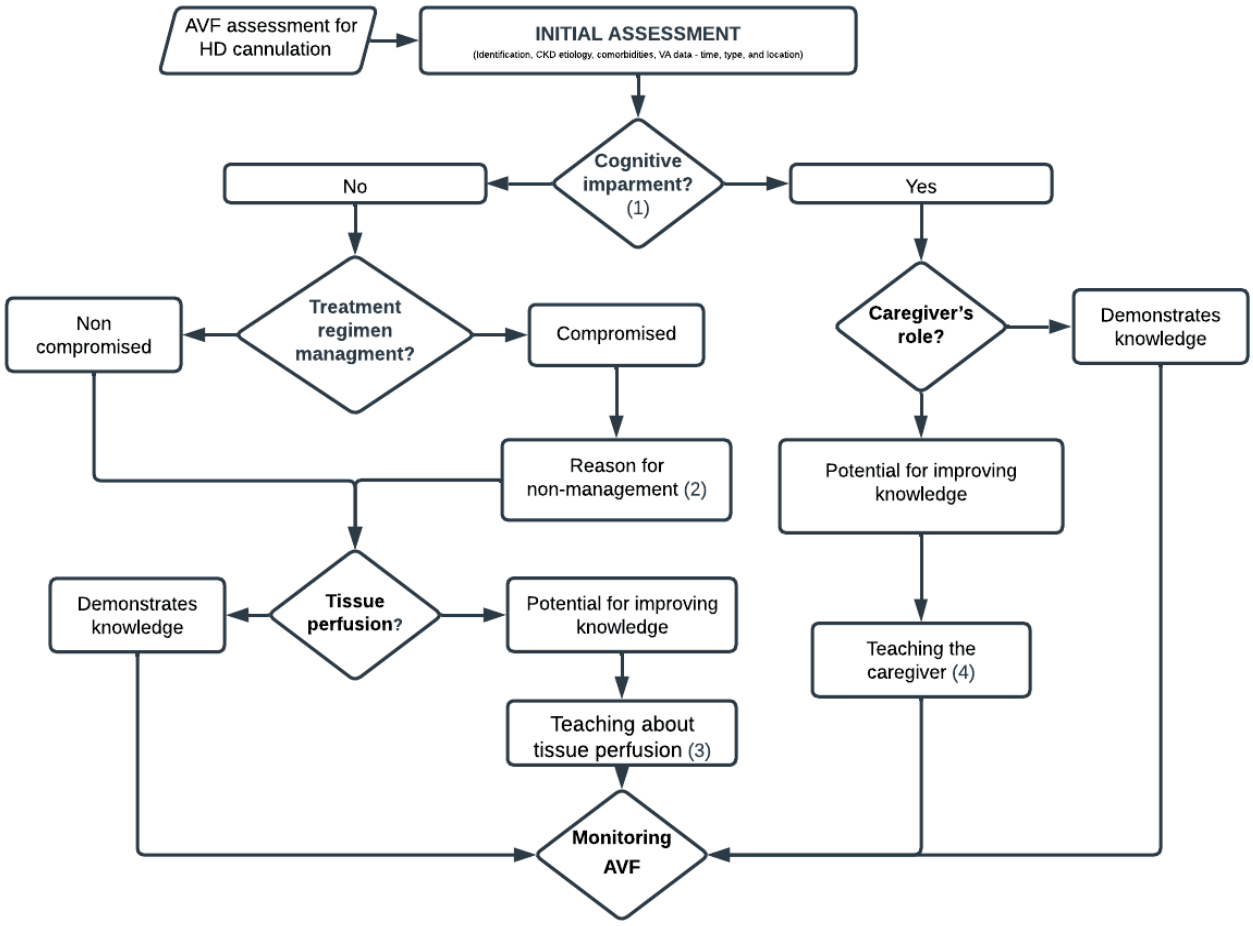
on the physical characteristics of the AVF. The paradigm generated by the MAGIC workgroup is the starting point of this study, which seeks to develop it having as objective its use in nursing AV consultations at a hospital unit in central Portugal.

The two main objectives of nursing consultations for HD patients with AVF are to assess the maturity of the newly created AVF and to determine the ideal cannulation technique. They are structured considering the quality standards for nursing care and the frameworks set by the International Classification for Nursing Practice (ICNP) and Nursing Information Systems.

The nursing consultations are conducted in two phases. The first phase is entitled "Knowledge Assessment of the HD Patient with Mature AVF" (Figure 1) and focuses on the CKD patient's capacity for self-care of the AVF. It is organized into five moments: i) initial assessment; ii) cognitive impairment assessment; iii) therapeutic regimen management; iv) tissue perfusion; v) and the caregiver's role. During this consultation phase, two key *foci* are relevant for the nursing intervention: tissue perfusion and therapeutic regimen management.

Figure 1

Knowledge Assessment of the HD Patient with Mature AVF



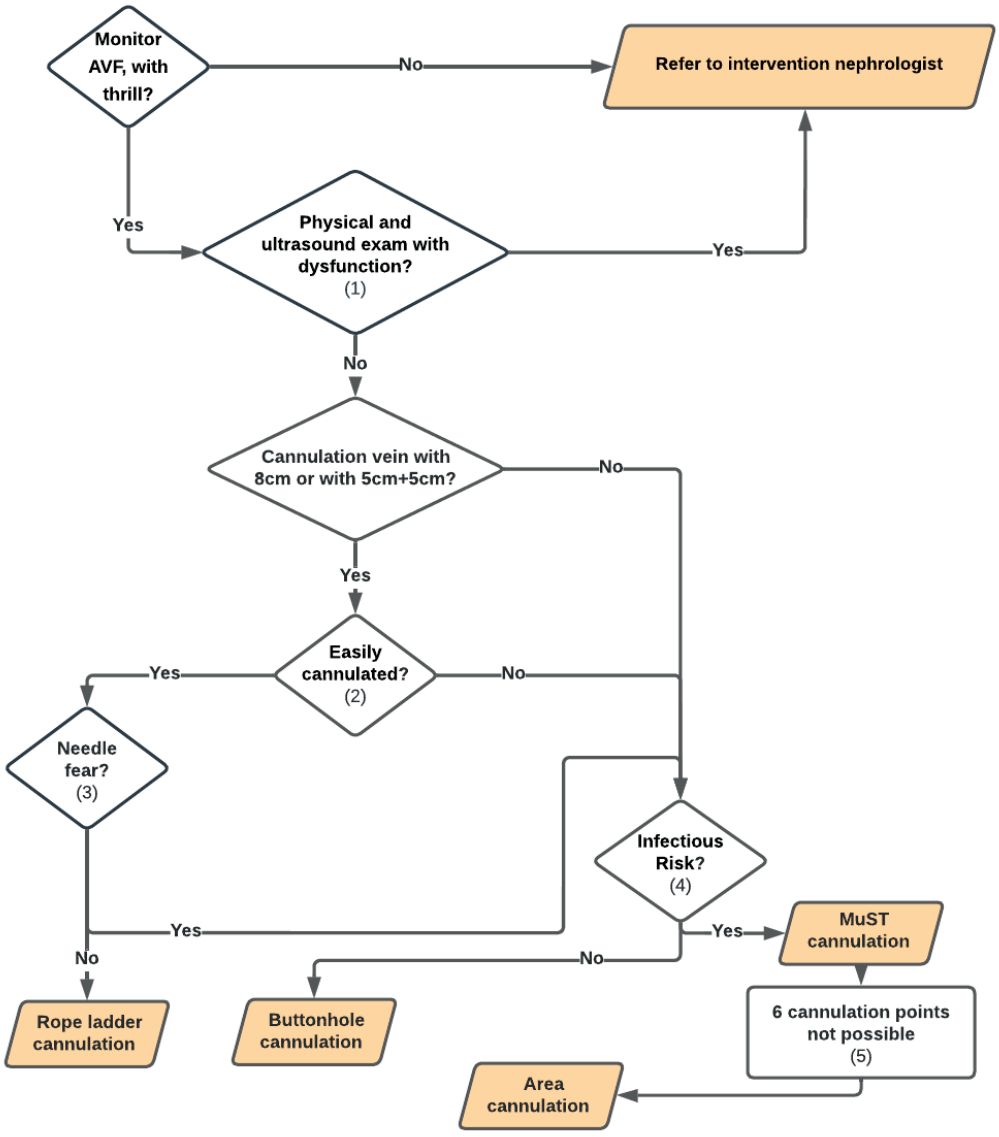
Note. 1 = Six-item Cognitive Impairment Test (6CIT); 2 = Reason for non-management - Focus: Therapeutic regimen management; Nursing diagnosis: Impaired therapeutic regimen management; Intervention: Assess therapeutic regimen management, encourage adherence to the therapeutic regimen, provide reading material on therapeutic regimen management, direct to health service, teach about complications, teach about treatments, promote awareness, assist in identifying the reasons hindering therapeutic regimen management, assist in identifying the health beliefs hindering therapeutic regimen management, encourage involvement in therapeutic regimen management. 3 = Teach about tissue perfusion - Focus: Tissue perfusion; Nursing diagnosis: Potential for improving knowledge to optimize tissue perfusion; Intervention: Assess knowledge to optimize tissue perfusion, teach about tissue perfusion; 4 = Teach the caregiver - Focus: the caregiver's role; Nursing diagnosis: Potential for improving the caregiver's knowledge about care delivery; Intervention: Assess the caregiver's knowledge about care delivery, teach the caregiver about complications, teach the caregiver about regimen management.

The second phase of the nursing consultation includes "The Decision-making Model for AVF Cannulation" (Figure 2). In this phase, physical examination, ultrasound examination, fear of needles assessment, and risk of infection assessment are conducted to evaluate the vascular access and determine the optimal cannulation technique. The physical examination procedure was adapted from the *Fistula First Catheter Last Workgroup* Coalition program (Lok et al., 2020). The ultrasound assessment evaluates the draining vein's diameter (minimum 4 mm), the depth (maximum 6 mm), the supply artery's internal flow (minimum 500 ml/min), and the cannulation segment (minimum 8 cm; British Renal Society, 2018; Ibeas et al., 2017; Robbin et al., 2018).

Creating a targeted and structured nursing consultation for patients with AVF allows for determining the optimal cannulation technique, considering the physical and ultrasound characteristics of the AVF, and addressing the patient's preferences and concerns. Marticorena (2019) developed the concept of an access procedure station (APS), a new healthcare model aimed at optimizing cannulation in HD initiation. This innovative clinical care delivery model creates an environment favorable to patient empowerment in the different aspects of their vascular access, directing care to individual needs (Kumbar et al., 2020).

Figure 2

The decision-making model for AVF cannulation



Note. 1 = Physical criteria for referral due to dysfunction: Inflammatory signs, arm pain at rest, signs of peripheral ischemia, pulse increase test without engorgement, arm elevation without collapse of the draining vein (Correia et al., 2020; Sousa et al., 2013). Ultrasound criteria for referral due to dysfunction: AVF internal flow <500ml/min, caliber reduction in the draining vein >50%, depth >6cm - no indication for transposition surgery (Ibeas et al., 2017); 2 = Easily cannulated vein corresponds to PHYSICAL EXAMINATION criteria; inspection: no inflammatory signs, edema or peripheral ischemia; palpation: easily palpable, low or absent tortuosity; auscultation: systo-diastolic murmur along the entire venous pathway without the presence of a sharp systolic sound. ULTRASOUND EXAM criteria: depth < 6mm, diameter > 4mm with the use of a tourniquet, proximity of the draining vein to an artery (British Renal Society, 2018; Correia et al., 2020; Ibeas et al., 2017; Lok et al., 2020; Pinto et al., 2021); 3 = Assess fear of needles - Pain measurement with a visual scale coded from 1-10; values equal to or greater than eight are considered cut-off points (Kal et al., 2020); 4 = Risk of infection - Adaptation of the British Renal Society's questions for infection screening (2018). The affirmative answer to at least one of the questions suggests the presence of infectious risk; 5 = The MuST cannulation technique requires a minimum pathway of 8 cm for safe cannulation; criteria such as venous tortuosity or proximity to the AVF supply artery may preclude the determination of the six cannulation sites required for the technique (Peralta et al., 2021).

The nursing consultation instrument for HD patients with vascular access was designed to support decision-making and the transmission of information collected in the nursing consultation to future clinical judgments. Therefore, this study aims to build and validate the decision-making instrument for optimal AVF cannulation in HD patients.

Methodology

This methodological study was conducted in a central hospital in the central region of Portugal between October and November 2021. The *Delphi* method was used for face and content validation, allowing health professionals to anonymously build a consensus of opinions on a given topic based on their experiences (Humphrey-Murto et al., 2017). Due to the lack of scientific evidence identified by Pinto et al. (2021), the *Delphi* method was used to obtain a clear consensus from a group of experts on the topic of HD cannulation, particularly regarding the selection of the optimal cannulation technique.

The size of a *Delphi* panel can vary from study to study, and there is no agreement on the minimum number needed to constitute the panel of experts. Nevertheless, a minimum of three experts per professional group and a final odd-numbered total were defined to break any possible ties. The sample was intentionally defined, and a group of 27 experts experienced in HD or the approach to vascular access in chronically ill patients was invited to participate. The inclusion criteria were: i) to be a nurse with ten or more years of experience in HD; ii) to be a university teacher teaching content related to the nursing process and approach to chronic HD patients with vascular access; iii) to be an interventional nephrologist in HD vascular access.

This study was conducted in two rounds. In the first round, the instrument's first version was built and provided in paper format to all experts participating in the study. The experts wrote improvement suggestions on the instrument, which were considered for restructuring the second version.

In the second round, an electronic questionnaire was designed to analyze the answers through the percentage of agreement on the instrument's blocks and sub-topics and the content validity index (CVI) according to the *Delphi* method (Hohmann et al., 2018). To assess the overall agreement, the experts were asked about the relevance of all the instrument's blocks, and the agreement percentage was calculated according to the formula: % agreement = $\frac{\text{No. of experts who agree}}{\text{Total no. of experts}}$ x100. A percentage higher than 90% was expected. Regarding the relevance/representativeness analysis, the answers were scored as follows: 1 = *item not relevant or not representative*; 2 = *item needs significant revision to be representative*; 3 = *item needs minor revision to be representative*; 4 = *item relevant or representative*. Items receiving a score of 1 or 2 were revised or eliminated. The validation questionnaire also included an area for suggestions where the experts gave their opinion on each specific context.

The CVI value was calculated using the formula: . An overall value of 0.8 was considered representative of a minimum agreement, and values higher than 0.9 showed a good level of agreement (Alexandre & Coluci, 2011; Pasquali, 2010).

The present study obtained a favorable opinion (code CHUC-106-20) from the hospital's Ethics Committee. All experts were informed of the study's objectives and the confidentiality of the data provided. They read and confirmed their informed consent forms.

Results

The instrument supporting the decision-making model for AVF cannulation in HD patients was validated after two rounds. All invited experts accepted to participate in the study. The group of experts consisted of 21 nurses (77.8%), three nephrologist physicians (11.1%), and three university teachers (11.1%), for a total of 27 professionals. Most were women (73.1%), and their overall professional experience was high, with 92.5% of the experts having at least 11 years of experience and 81.4% with more than 11 years of experience in HD.

The instrument supporting the decision-making model for AVF cannulation was divided into four blocks: i) physical assessment; ii) ultrasound assessment; iii) vascular access graphical representation; iv) observations. The experts reached an overall face agreement of 100% in all the blocks, proving the pertinence of the instrument's structure (Table 1).

Table 1

Content agreement percentage after round 2

	Agreement (%)
Physical assessment	100
Ultrasound assessment	100
Vascular access graphical representation	100
Observations	100
TOTAL	**100**

Table 2 shows all items of the instrument's blocks. The CVI was calculated for each item of the four blocks, and the overall level of agreement (0.94) shows a good level of acceptance among the experts, with the lowest CVI value (0.81%) recorded in the item "Secondary vein."

Table 2

Content validity index after round 2

	Content validity index
Physical assessment	
Arm elevation test	0.96
Inspection	1
Dominant draining vein	1
Secondary vein	0.81
Pulse	0.93
Fremitus	1
Pulse rise test	0.88
Heart murmur	0.96
Cannulated venous pathway	1
Infectious risk	0.88
Needle phobia	0.85
Ultrasound assessment	
Venous depth	0.96
Venous diameter	0.96
Doppler-calculated internal flow	0.93
Segment with decreased diameter	0.96
Vascular access graphical representation	
AV arm photograph with dermographic marks	0.93
Observations	
Supplementary written instructions on the cannulation technique	1
Global content validity index	**0.94**

Discussion

During the process of face and content validation, the diversity of the professional experience of the experts involved proved to be decisive, as it added different theoretical and practical sensitivities to the topic addressed. Similar studies also emphasize the importance of this type of validation in practical use instruments (Alexandre & Coluci, 2011).

The experts reached a consensus with an overall CVI of ≥ 0.9, demonstrating the instrument's capacity to achieve its purpose. It is also worth highlighting the agreement values where the experts' unanimity was achieved, and the maximum CVI values reached in items "inspection", "dominant draining vein", "fremitus", "cannulated venous pathway", and "written instructions on the cannulation technique" for the patient with AVF.

Conclusion

Using measurement instruments to support clinical decision-making has been crucial in current practice. Validating instruments that guide the practice associated with developing health technologies benefits the nursing profession since they make it possible to guide nursing care and improve care quality. A nursing consultation based on a model of theoretical references ensures a well-grounded and safer practice.

This decision-making model has as one of its added values the evidence that the nurse has the necessary instruments to decide, together with the patient, about the AVF state of maturation and the ideal future cannulation technique. This decision-making is planned in a separate room, not the HD unit, with no time pressure to initiate treatment. Therefore, the decision-making model for cannulation and the proposed support instrument are objective resources for improving quality and ensuring the application of the best clinical practices in AVF cannulation for HD patients in nursing consultation settings.

Author contribuitions

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Data curation: Pinto, R., Duarte, Salgueiro, A., Fernandes, I.

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Resources: Pinto, R.
Software: Pinto, R.
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Visualization: Pinto, R., Duarte, F., Mata, F., Sousa, C., Salgueiro, A., Fernandes, I.
Writing – original draft: Pinto, R., Duarte, F., Mata, F., Sousa, C., Salgueiro, A., Fernandes, I.
Writing – review & editing: Pinto, R., Mata, F., Sousa, C., Salgueiro, A., Fernandes, I.

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