

# Arteriovenous fistula maturation clinical assessment for hemodialysis: a scoping review

Avaliação clínica da maturação da fístula arteriovenosa para hemodiálise: revisão de escopo  
Evaluación clínica de la maduración de la fístula arteriovenosa para hemodiálisis: revisión de alcance

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## How to cite:

Correia BR, Brandão MA, Lopes RO, Silva PC, Zaccaro KR, Benevides AB, et al. Arteriovenous fistula maturation clinical assessment for hemodialysis: a scoping review. Acta Paul Enferm. 2021;34:eAPE00232.

## DOI

<http://dx.doi.org/10.37689/acta-ape/2021AR00232>



## Keywords

Arteriovenous fistula; Renal dialysis; Health evaluation; Postoperative care

## Descritores

Fístula arteriovenosa; Diálise renal; Avaliação em saúde; Avaliação em enfermagem; Cuidados pós-operatórios

## Descriptores

Fístula arteriovenosa; Diálisis renal; Evaluación en salud; Cuidados posoperatorios

## Submitted

February 8, 2020

## Accepted

June 17, 2020

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## Abstract

**Objective:** To map the available research evidence for arteriovenous fistula maturation clinical assessment.

**Methods:** A scoping review, with a search conducted between October and November 2019 at JBI, Cochrane, Virtual Health Library, PubMed, and CINAHL. Studies with patients over 18 years old, with pre-dialysis chronic kidney disease or already under hemodialysis, who underwent arteriovenous fistula surgery were included; available text; and in English, Spanish, and Brazilian Portuguese. Studies related to the postoperative phase or related to care with prostheses/arteriovenous grafts were excluded.

**Results:** One thousand nine hundred and fifty-four eligible studies were identified; 38 made up the final sample. The study comprised studies between 1998 and 2018, with an international scope of the theme (94.7%). The professional who performed the assessment was predominantly the nurse or nursing team (47.4%), and assessment started in the immediate post-surgical period, even months after surgery. Among the clinical assessment techniques, 23 studies (60.5%) recommended physical examination and 15 (39.5%) the combination of medical history and physical examination.

**Conclusion:** This review presented the mapping of evidence, in which arteriovenous fistula clinical assessment must include medical history and physical examination. Several elements related to the permeability and vascular responses of the access were presented. There was a predominance of professional nurses as evaluators. There was need for training to carry out the assessment, in addition to a more comprehensive assessment, with the application of the Nursing Theory and Standardized Languages and Process, which may provide with a new field of research and development in the area.

## Resumo

**Objetivo:** Mapear as evidências de pesquisa disponíveis para avaliação clínica da maturação da fístula arteriovenosa.

**Métodos:** Estudo do tipo *Scoping review*, com busca realizada entre outubro a novembro de 2019 nas bases de dados JBI, Cochrane, Biblioteca Virtual em Saúde, PubMed, e CINAHL, sendo incluídos estudos com pacientes maiores de 18 anos, com doença renal crônica pré-dialítica ou já em hemodiálise, submetidos à cirurgia da fístula arteriovenosa; texto disponível; e idiomas inglês, espanhol ou português. Foram excluídos estudos relacionados a fase pós-operatória ou relacionados a cuidados com próteses/enxertos arteriovenosos.

**Resultados:** Foram identificadas 1954 publicações elegíveis, dos quais 38 compuseram a amostra final. O estudo compreendeu publicações entre 1998 e 2018, com abrangência internacional do tema (94,7%). O profissional executor da avaliação foi predominantemente o enfermeiro ou equipe de enfermagem (47,4%), e a avaliação teve início no pós-cirúrgico imediato, até meses após a cirurgia. Dentre as técnicas de avaliação

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Conflicts of interest: nothing to declare.

clínica, 23 estudios (60,5%) recomendaron el examen físico e 15 (39,5%) la combinación anamnesis y examen físico.

**Conclusão:** A presente revisão apresentou o mapeamento de evidências, nas quais a avaliação clínica da fístula arteriovenosa deve incluir anamnese e exame físico, sendo apresentados vários elementos ligados a permeabilidade e respostas vasculares do acesso. Houve a predominância do profissional enfermeiro como avaliador, sendo ressaltada a necessidade do treinamento para execução da avaliação, além de uma avaliação mais abrangente, com aplicação do Processo e Teorias de Enfermagem, e Linguagens Padronizadas, o que pode propiciar um novo campo de investigação e desenvolvimento na área.

## Resumen

**Objetivo:** Mapear las evidencias de investigación disponibles para evaluación clínica de la maduración de la fístula arteriovenosa.

**Métodos:** Estudio tipo *scoping review*, cuya búsqueda fue realizada entre octubre y noviembre de 2019 en las bases de datos JBI, Cochrane, Biblioteca Virtual em Saúde, PubMed y CINAHL. Se incluyeron estudios con pacientes mayores de 18 años, con enfermedad renal crónica predialítica o ya en hemodiálisis, sometidos a cirugía de fístula arteriovenosa y textos disponibles en inglés, español o portugués. Se excluyeron estudios relacionados con la fase posoperatoria o relacionados con cuidados de prótesis/injertos.

**Resultados:** Se identificaron 1.954 publicaciones elegibles, de las cuales 38 formaron parte de la muestra final. El estudio comprendió publicaciones entre 1998 y 2018, con alcance internacional del tema (94,7 %). El profesional que ejecutó la evaluación fue predominantemente el enfermero o el equipo de enfermería (47,4 %) y la evaluación comenzó en el posoperatorio inmediato, hasta meses después de la cirugía. Entre las técnicas de evaluación clínica, 23 estudios (60,5 %) recomendaron el examen físico y 15 (39,5 %) la combinación entre anamnesis y examen físico.

**Conclusión:** La revisión presentó el mapeo de evidencias, en las cuales la evaluación clínica de la fístula arteriovenosa debe incluir anamnesis y examen físico. También se presentaron varios elementos relacionados con la permeabilidad y respuestas vasculares del acceso. Hubo una predominancia del profesional enfermero como evaluador y se destaca la necesidad de entrenamiento para llevar a cabo la evaluación, además de una evaluación más abarcadora, con aplicación del proceso y teorías de enfermería y un lenguaje estandarizado, lo que puede proporcionar un nuevo campo de investigación y desarrollo del área.

## Introduction

Among the modalities of renal replacement therapy to deal with chronic kidney disease (CKD), hemodialysis is the main one, reaching 70% to 90% of patients, with all needing adequate vascular access.<sup>(1,2)</sup> The alternatives are arteriovenous fistula (AVF) and central venous catheters (CVC). AVF is considered the gold standard for better indicators for risk of infections, hospitalizations, occurrence of central venous stenosis, mortality and costs than CVC.<sup>(3-7)</sup> So, the AVF creation and monitoring strategies become relevant.<sup>(2,8,9)</sup>

AVF is an autogenous anastomosis between an artery and a vein. After its creation, a continuous flow from the artery to the vein initiates a series of changes, altering the structure of the wall, generating a shear stress and rapidly increasing blood flow during the first 24 hours. These changes make AVF adequate to withstand repeated punctures of dialysis therapy; and must go through the maturation phase, which takes about four to six weeks, involving changes such as increased blood flow to 500 ml/minute, minimum diameter of 4 mm and easy viewing.<sup>(7,10)</sup> However, a quarter to a third of fistulas never mature properly.<sup>(11)</sup> A recent study found that only 17.1% of hemodialysis patients used the fistula after two months and 54.7% after four months of creation.<sup>(12)</sup>

Assessment of these changes must involve observation and assessment of vascular access through physical examination; and surveillance, which refers to periodic assessment using tests that involve special instrumentation, such as the use of Doppler Ultrasound (DUS) and angiography.<sup>(10,13-15)</sup> Overall, both assessments are complementary.<sup>(16-18)</sup>

The physical assessment of monitoring of access dysfunction during the maturation phase, the focus of this article, has been considered convenient, simple, economical and of relevance.<sup>(16)</sup> A study developed in a radiological unit demonstrated that this assessment obtained high sensitivity values (82%) for the detection of stenosis. Physical examination was a useful tool, especially when applied in centers that do not have ultrasound for surveillance.<sup>(17)</sup> Moreover, with less usage limits than DUS, such as cost and need for a qualified operator.<sup>(9)</sup>

A systematic review identified physical examination as an effective and accurate tool for detecting AVF dysfunction; however, it indicated its inadequate performance. It was concluded that nursing care is closer, regular and frequent to patients with AVF, justifying the conduct of this assessment by nurses.<sup>(9)</sup> A study with Portuguese hemodialysis nurses from eight specialized centers showed weakness related to the skills and knowledge to perform this physical assessment.<sup>(19)</sup> In addition, there are

variations in institutional recommendations on elements of AVF assessment with consequences on the delimitation of professional actions.

Considering the weaknesses pointed out, it is understood that it is necessary to map the available evidence about the elements used for the clinical assessment and to characterize the techniques used by the professionals who have performed it, in order to facilitate further standardization for professional practices and produce better results in monitoring AVF maturation.

The study aimed to map the research evidence on AVF maturation clinical assessment in patients with CKD.

## Methods

This is a scoping review study with systematic review guided by the methodology of the Joanna Briggs Institute (JBI) and Joanna Briggs Collaborating Centers.<sup>(20,21)</sup> The selection of this review strategy was based on its purposes of mapping the body of knowledge on a topic and incorporating a range of study designs and research methodologies.<sup>(22)</sup>

The steps taken were: definition and alignment of the objectives and issues of the review; development and alignment of inclusion criteria with objectives and issues; description of the planned approach for selecting, extracting and mapping research evidence; search for evidence; selection of evidence; extraction of evidence; mapping of evidence; summarizing the evidence in relation to the objective and the issue; consultation with information scientists, librarians and/or experts.

The research question used PCC strategy, being Population - adults with CKD; Concept - AVF maturation clinical assessment elements for hemodialysis; and Context - post-operative period for making AVF, in any hospital setting. The question was: What are the elements of maturation to be clinically assessed in AVF for hemodialysis in the postoperative period of its preparation in adult patients with CKD?

Inclusion criteria were: studies carried out with patients over 18 years old, with pre-dialysis CKD

or under hemodialysis, who underwent AVF surgery; full text available; and in English, Spanish, and Brazilian Portuguese. Studies unrelated to the postoperative phase related to care with arteriovenous prostheses/grfts and which did not address clinical assessment during the maturation phase were excluded.

Search took place in October and November 2019 at JBI, Cochrane, all databases of the Virtual Health Library, PubMed and CINAHL. Evidence from the gray literature was sought from the CAPES Catalog of Theses and Dissertations, documents on websites of official bodies, guidelines and manuals from international and national institutions, and books. There was no time limitation for searching. The descriptors in Health Sciences (DECS) and Medical Subject Headings (MeSH) linked to the research question were used (Chart 1).

**Chart 1.** Estratégia de busca e descritores utilizados

PCC strategy	DECS descriptors in Brazilian Portuguese	MESH terms
POPULATION: Adult patients with CKD	<i>Adulto</i> OR <i>Adulto jovem</i> OR <i>Pessoas de meia idade</i> AND <i>Insuficiência renal</i>	Adult OR Young adult OR Middle aged AND Chronic kidney failure
CONCEPT: Indicators for clinical assessment of AVF maturation for hemodialysis	<i>Fístula arteriovenosa</i> AND <i>Avaliação em saúde</i> OR <i>Avaliação em enfermagem</i> OR <i>Exame Físico</i> OR <i>Anamnese</i> AND <i>Diálise Renal</i>	Arteriovenous fistula AND Health Care Evaluation Mechanisms OR Nursing Assessment OR Physical Examination OR Medical History Taking AND Renal Dialysis
CONTEXT: Post-operative period for making AVF in any hospital setting	<i>Período pós-operatório</i> OR <i>Cuidados pós-operatórios</i>	Postoperative period OR Postoperative Care

The identified citations were collected and uploaded to Mendeley<sup>®</sup> and duplicated removed. The exploratory reading of titles and abstracts was performed by peers of reviewers independently. Studies that were related to the research question and met criteria for language inclusion and availability of the full text were judged. Disagreements were resolved by consensus between peers or by the assessment of a third reviewer, when disagreement was maintained. Then, the pre-selected studies were read in full to assess the content as to their contribution to understanding the phenomenon studied and subsequent data synthesis. Subsequently, consulting the reference lists of articles in search of additional studies resulted in the inclusion of eight more studies.

All research, decisions and steps were documented and filed by the main reviewer.

Study search and selection followed the JBI recommendations regarding presentation of the results with a checklist adapted from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).<sup>(20)</sup>

From the final corpus of the included studies, data were extracted with a specific form for mapping the title, authorship, year of publication, country of origin, objective, study population and sample size (when applicable), methods, study design, professional in charge of clinical assessment, assessment duration (if applicable), and assessment techniques. Subsequently, they were inserted in an Excel® spreadsheet, from which the characterization of the studies and grouping, synthesis and description of the results proceeded from the research question.

## Results

One thousand one hundred and fifty-four studies were identified, of which 38 made up the final

sample. In the search process flow (Figure 1), 1940 matches were initially found. Another fourteen were added from references (n=8) and gray literature (n=6), removing duplicates (n=4). 1,950 studies were obtained to read the titles and abstracts. As they did not answer the research question, 1831 were excluded. The complete texts of the remaining 119 were assessed for eligibility, and 81 were excluded. Thirty-eight studies were included in the final data extraction and analysis process.

Chart 2 presents the selected studies according to authorship/year, title, study design, objective, population/sample and country of origin. As noted, studies published in the last 20 years, between 1998 and 2018, were found. Of the types of studies, 29 are articles (76.3%); six are clinical guidelines (15.8%); two are manual (5.3%); one is a book source (2.6%). Most studies were international (n=36; 94.7%), with a prevalence of studies from the United States of America (USA) (n=14; 36.8%).

The studies pointed out that, in relation to the professionals in charge of assessment, nephrologist nurses or nursing staff predominated (n=18; 47.4%), followed by nephrologists, interventionists

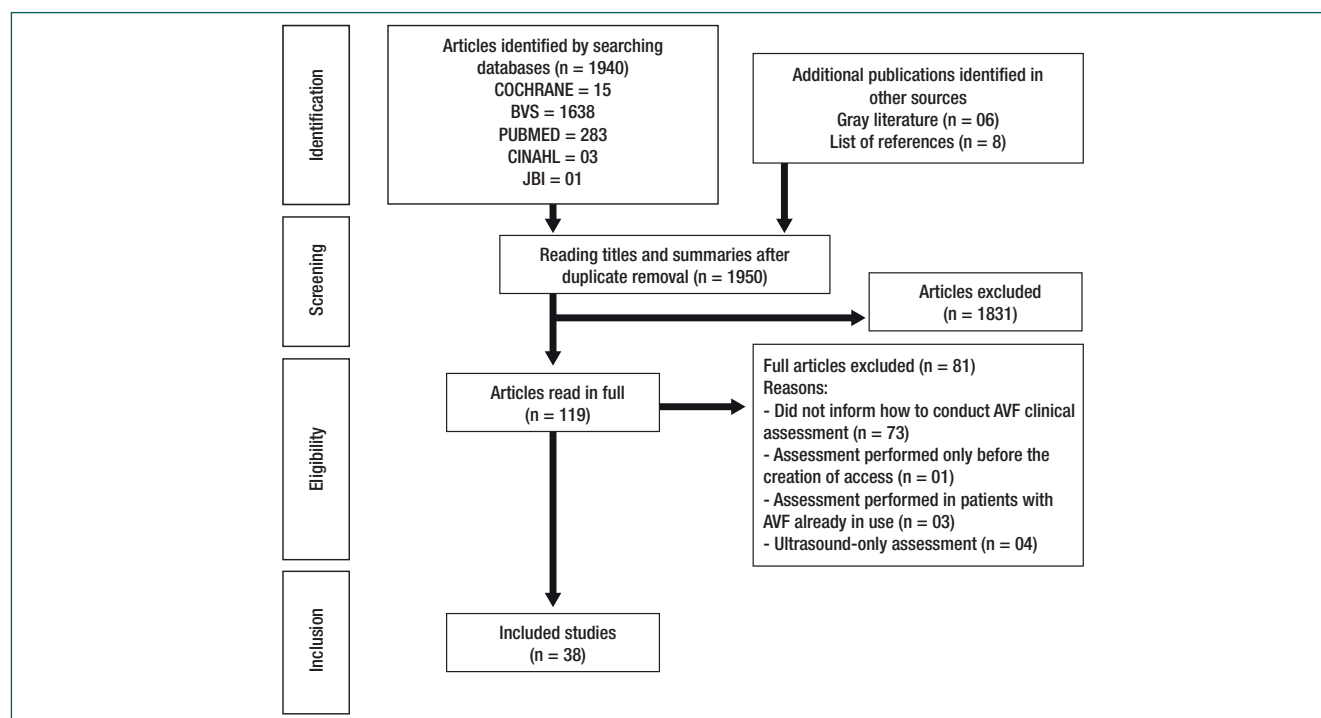


Figure 1. PRISMA flowchart of the literature search process

**Chart 2.** Description of studies regarding authorship and year of publication, title, study design and country

Authorship/Year	Title	Study design	Objective	Population/sample	Country
Schmidli et al. <sup>(10)</sup> 2018	Vascular Access: 2018 Clinical Practice Guidelines of the European Society for Vascular Surgery	Review	To establish guidelines for clinical practice for surgeons and physicians involved in caring for patients under hemodialysis and with vascular access.	Not applicable.	Switzerland
National Kidney Foundation <sup>(14)</sup> 2006	Clinical Practice Guidelines and Clinical Practice Recommendations	Review	To disseminate clinical guidelines and recommendations for vascular access issued by the National Kidney Foundation working group.	Not applicable.	USA
Ibeas et al. <sup>(15)</sup> 2017	<i>Guía Clínica Española del Acceso Vascular para Hemodiálisis</i>	Review	To review the evidence in the literature and establish recommendations in the management of vascular access for hemodialysis that facilitate decision-making in clinical practice.	Not applicable.	Spain
Beathard <sup>(23)</sup> 1998	Physical examination of the dialysis vascular access	Theorizing	To review the aspects involved in physical examination of vascular access for hemodialysis.	Not applicable.	USA
Coentrão <sup>(24)</sup> 2012	Physical examination of dysfunctional arteriovenous fistulae by non-interventionalist: a skill worth teaching	Observational prospective	To analyze the accuracy of physical examination in the assessment of AVF dysfunction by non-interventionists in comparison with angiography.	177 patients with AVF dysfunction.	Portugal
McLafferty <sup>(25)</sup> 2007	Outcome of a comprehensive follow-up program to enhance maturation of autogenous arteriovenous hemodialysis access	Prospective cohort	To analyze the result of a comprehensive program for monitoring autogenous access for hemodialysis when performed by the vascular surgeon.	113 patients undergoing AVF construction surgery.	USA
Sidawy <sup>(26)</sup> 2008	The Society for Vascular Surgery: Clinical practice guidelines for the surgical placement and maintenance of arteriovenous hemodialysis access	Review	To develop practical guidelines for the placement and maintenance of arteriovenous access, in order to maximize the percentage and functionality of autogenous arteriovenous accesses that are made.	Not applicable.	USA
Leivaditis <sup>(27)</sup> 2014	Vascular access for hemodialysis: postoperative evaluation and function monitoring	Review	To review aspects involved in postoperative monitoring of vascular access for hemodialysis.	Not applicable.	Greece
Ferring <sup>(28)</sup> 2014	Accuracy of early postoperative clinical and ultrasound examination of arteriovenous fistulae to predict dialysis use	Randomized	To assess the accuracy of clinical assessment and early ultrasound in predicting AVF functionality.	208 patients undergoing AVF construction surgery.	England
Robbin <sup>(29)</sup> 2002	Hemodialysis arteriovenous fistula maturity: US evaluation	Comparative retrospective	To compare objective sonographic criteria for native AVF maturation with the subsequent results of fistula and clinical assessment by hemodialysis nurses.	69 patients in the postoperative period of AVF construction surgery submitted to ultrasound assessment.	USA
Leon <sup>(30)</sup> 2008	Physical examination of arteriovenous fistula by a renal fellow: does it compare favorably to an experienced intervention a list?	Cross-sectional prospective	To examine the accuracy of physical examination compared to angiography when performed by nephrologists.	Nephrologists' assessment of 45 cases of AVF dysfunction and interventionist assessment of 142 patients with fistula dysfunction.	USA
Beaumont Hospital <sup>(31)</sup> 2012	Guidelines on the Management of Arteriovenous Fistula and Grafts	Review	To maximize the efficiency and safety of renal patients with AVF and arteriovenous graft.	Not applicable.	Ireland
European Dialysis and Transplant Nurses Association/ European Renal Care Association <sup>(32)</sup> 2015	<i>Manual de boas práticas de enfermagem para a fistula arteriovenosa</i>	Theorizing	Chapter analysis whose objective is to describe aspects related to AVF, including post-operative assessment.	Not applicable.	Portugal
Thomas <sup>(33)</sup> 2013	Renal Nursing	Theorizing	Book chapter describing aspects involved in AVF clinical assessment.	Not applicable.	England
Mattiazzi <sup>(34)</sup> 1999	<i>Evaluación clínica del acceso vascular</i>	Theorizing	To address the importance of AVF clinical assessment using physical examination.	Not applicable.	Argentina
Beathard <sup>(35)</sup> 2005	An algorithm for the physical examination of early fistula failure	Theorizing	To review and define an approach for early assessment of failure in AVF maturation using physical examination.	Not applicable.	USA
Kian <sup>(36)</sup> 2005	The new arteriovenous fistula: the need for earlier evaluation and intervention	Review	To review the importance of early assessment and intervention in the maturing AVF.	Not applicable.	USA
Asif <sup>(37)</sup> 2006	Early arteriovenous fistula failure: a logical proposal for when and how to intervene	Review	To describe the current understanding of fistula maturation and early failure and review changes in blood flow and size that occur in a newly created AVF and present information on when and how to intervene to identify and recover fistulas with early failure.	Not applicable.	USA
Ohira <sup>(38)</sup> 2006	2005 Japanese Society for Dialysis Therapy Guidelines for vascular access construction and repair for chronic hemodialysis	Review	To establish Japanese guidelines for the construction and repair of vascular access for hemodialysis, standardizing procedures related to vascular access.	Not applicable.	Japan

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Authorship/Year	Title	Study design	Objective	Population/sample	Country
Jiménez Almonacid <sup>(39)</sup> 2007	<i>Definición de procesos e indicadores para la gestión de accesos vasculares para hemodiálisis</i>	Methodological	To define processes for the management of vascular access for hemodialysis and assess these processes.	Medical records of patients with vascular access for hemodialysis.	Spain
Levine <sup>(40)</sup> 2008	A challenge for nephrologists -increasing fistula maturation rates, reducing fistula maturation time, and decreasing dialysis catheter prevalence in the United States	Review	To reflect on the importance of establishing AVF for hemodialysis.	Not applicable.	USA
McCann <sup>(41)</sup> 2008	Vascular Access Management 1: An overview	Review	To describe the aspects involved in the management of vascular access for hemodialysis.	Not applicable.	Ireland
Nassar <sup>(42)</sup> 2008	Endovascular Management of the "Failing to Mature" Arteriovenous Fistula	Review	To describe the behaviors in face of failure in AVF maturation.	Not applicable.	USA
Malovrh <sup>(43)</sup> 2010	Non-matured arteriovenous fistulae for haemodialysis: diagnosis endovascular and surgery treatment	Review	To review the AVF maturation process and provide with information on how to obtain a mature fistula.	Not applicable.	Slovenia
Neves Junior <sup>(44)</sup> 2011	<i> Avaliação da perviedade precoce das fistulas arteriovenosas para hemodiálise</i>	Non-randomized prospective	To assess the early patency of AVFs, identifying factors related to their failure.	31 patients who underwent AVF.	Brazil
Ahmed <sup>(45)</sup> 2012	Outcomes of arteriovenous fistula for hemodialysis in Sudanese patients: single-center experience.	Randomized prospective	To describe the experience of a dialysis center in creating AVF and assess the success rate and common complications.	73 hemodialysis patients.	Sudan
Rose <sup>(46)</sup> 2013	Hemodialysis Access	Review	To describe factors related to vascular access for hemodialysis.	Not applicable.	USA
Salimi <sup>(47)</sup> 2013	Assessment of effects of upper extremity exercise with arm tourniquet on maturity of arteriovenous fistula in hemodialysis patients	Randomized	To investigate the effects of manual exercise using a tourniquet on the maturing AVF in patients with end-stage renal disease.	50 patients undergoing construction of AVF.	Iran
Sousa <sup>(48)</sup> 2013	Physical examination: How to examine the arm with arteriovenous fistula	Review	To gather and systematize knowledge about aspects of physical examination that allow the identification of AVF complications.	Not applicable.	Portugal
Huang <sup>(49)</sup> 2014	Compliance with Surgical Follow-up Does Not Influence Fistula Maturation in a County Hospital Population	Prospective	To examine follow-up rates and maturation rates after surgery to create a fistula in a municipal hospital with an indigent population.	203 patients undergoing AVF construction surgery.	USA
Malovrh <sup>(50)</sup> 2014	Postoperative assessment of vascular access	Review	To review and establish criteria for postoperative assessment of vascular access.	Not applicable.	Slovenia
López Alonso <sup>(51)</sup> 2015	<i>Influencia del ejercicio físico en el desarrollo de fistulas arteriovenosas nativas</i>	Randomized prospective	To assess the influence of an experienced nephrologist nurse in a controlled program of postoperative physical exercise on native AVF maturation in the month of its implantation.	68 patients in the postoperative period of AVF construction surgery.	Spain
Cheng <sup>(52)</sup> 2015	The reasons for the failure of the primary arteriovenous fistula surgery in patients with end-stage renal disease	Cross-sectional prospective	To analyze the reasons for the primary failure of AVF surgery and explore preventive measures.	819 patients undergoing surgery to create AVF.	China
Muftu <sup>(53)</sup> 2015	Proactive surveillance approach to guarantee a functional arteriovenous fistula at first dialysis is worth	Prospective cohort	To assess the impact of a proactive surveillance program on the functional access rate at the time of the first dialysis.	164 patients undergoing AVF construction surgery.	Belgium
Rosenberg <sup>(54)</sup> 2015	Prediction of Arteriovenous Fistula Dysfunction: Can it be Taught?	Cross-sectional prospective	To assess if it is possible to teach physical examination to students and verify the accuracy of the exam done by them in detecting stenosis when compared to the physical examination performed by interventionist professionals.	49 patients with suspected access dysfunction.	USA
Pereira <sup>(55)</sup> 2016	<i> Avaliação do tempo de maturação das fistulas rádio-cefálicas para hemodiálise</i>	Retrospective observational	To assess whether the length of radio-cephalic AVF maturation is influenced by gender and age or by CKD.	66 medical records of patients undergoing radio-cephalic AVF	Brazil
Martínez <sup>(56)</sup> 2017	Neuromuscular electro stimulation: a new therapeutic option to improve radio cephalic arteriovenous fistula maturation in end stage chronic kidney disease patients	Case-control prospective	To assess the utility of a neuromuscular electrostimulation program in AVF maturation.	36 patients submitted to the creation of AVF.	Spain
Rodrigues <sup>(57)</sup> 2018	<i> Avaliação de variáveis associadas à permeabilidade de fistulas arteriovenosas criadas por um nefrologista para fins de hemodiálise</i>	Retrospective cohort	To assess the success rate of AVF created by a nephrologist and identify clinical, laboratory and demographic variables that influence AVF patency.	101 patients with CKD.	Brazil

or vascular surgeons (n=16; 42.1%), and finally, a professional or specialized/trained team to deal specifically with AVF (n=6; 15.8%).

AVF post-surgical assessment length varied from the first postoperative hours to one year. Two

studies recommended the assessment in the first hours, initially every half hour, and then with decreasing intervals until discharge.<sup>(33,41)</sup> The weekly postoperative assessment;<sup>(55)</sup> on the 1<sup>st</sup>, 10<sup>th</sup> and 30<sup>th</sup> postoperative days;<sup>(44)</sup> or on the 1<sup>st</sup> day, 1<sup>st</sup> week and

**Chart 3.** Clinical elements for assessing AVF maturation

<p><b>MEDICAL HISTORY:</b></p> <ul style="list-style-type: none"> <li>- Access creation time<sup>(35,57)</sup></li> <li>- Location<sup>(35,49,53,56,57)</sup></li> <li>- Type<sup>(35,49,56)</sup></li> <li>- Patient characteristics (age, sex, race, BMI, smoking, etiology of CKD, comorbidities, blood pressure)<sup>(15,38,44,49,51,52,56,57)</sup></li> <li>- History of previous intravascular catheterization<sup>(35,38,44)</sup></li> <li>- History of previous dialysis<sup>(44,49)</sup></li> <li>- Medications in use<sup>(56)</sup></li> <li>- Biochemical parameter<sup>(56)</sup></li> </ul>
<p><b>INSPECTION:</b></p> <ul style="list-style-type: none"> <li>- Visible vein extension (&gt; 10 cm)<sup>(10,28,29,35,36,47,54-56)</sup></li> <li>- Very well developed, straight, without areas of irregularity or aneurysms<sup>(14,28,29)</sup></li> <li>- Signs of central venous stenosis: Edema in the arm, chest, neck or face<sup>(14,24,25,30,37,39,53)</sup></li> <li>- Signs of infection in the operative wound (flushing, edema, secretion, erythema, cellulitis, ulcerations, cracks)<sup>(10,14,27,31,32,41,47-49)</sup></li> <li>- Hematoma in the surgical wound<sup>(10,44,47,49)</sup></li> <li>- Seroma<sup>(54)</sup></li> <li>- Signs of theft syndrome: Pale, cyanotic limb, ulcerations, flaking, discoloration of the nail bed<sup>(14,46,48)</sup></li> <li>- Signs of venous hypertension syndrome: Edema of the arm, hyperpigmentation of the skin, collateral veins in the chest, ulcerations in the extremity<sup>(27,32,36,48)</sup></li> <li>- High output heart failure: increased expansion of the venous segment<sup>(48)</sup></li> <li>- Checking of accessory veins<sup>(14,25-27,30,32,34,39,42-44,48,50)</sup></li> <li>- Arm elevation test: Normal with the collapsing vein and abnormal with the non-collapsing vein (sign of stenosis)<sup>(10,14,15,24,26,27,30,43,46,48,53)</sup></li> <li>- Signs of venous stenosis (narrowing of the vein, sudden decrease/absence, aneurysms, edema of the extremity)<sup>(10,14,15,27,32,33,48)</sup></li> </ul>
<p><b>PALPATION:</b></p> <ul style="list-style-type: none"> <li>- Pulse: Normal - smooth, easily compressible and abnormal (sign of stenosis or inadequate maturation): hyperpulsatile, in a water hammer, or absent<sup>(10,14,15,23-28,30,34,35,37,40,42-44,46-48,50,51,53,54,56,57)</sup></li> <li>- Pulse increase test: Normal - with pulse increased above the occlusion point and abnormal: Weak or absent pulse above the occluded point<sup>(24,27,30,35,37,42,48,50,51,53)</sup></li> <li>- Signs of infection: increased temperature, abscess, hardening or fluctuations in the area<sup>(14,48)</sup></li> <li>- Palpation of depth (should not be too deep: less than 6 mm) and vein diameter: at least 6 mm<sup>(10,14,25,26,28,29,35,46,48,56,57)</sup></li> <li>- Thrill: Normal - present, uniform throughout the entire venous path; and abnormal (sign of stenosis), if only systolic or absent<sup>(10,15,23-31,33-41,43,44,46-57)</sup></li> <li>- Acknowledge of accessory veins: perform manual occlusion of the venous segment, the presence of thrill below the occluded point is indicative of the presence of accessory veins<sup>(15,23,34-37,40,42-44,46,48,50)</sup></li> <li>- Theft syndrome sign: cold skin, decreased radial pulse, pain on mobilizing the hand<sup>(48)</sup>, positive Allen test<sup>(31)</sup></li> <li>- Signs of venous hypertension syndrome: edema, pain in the hand and fingers<sup>(48)</sup></li> <li>- High output heart failure: increased intensity of thrill and murmur, increased arterial pulse, AVF occlusion decreases heart rate (Nicoladoni Branham sign)<sup>(48)</sup></li> <li>- Just-anastomotic stenosis: presence of a prominent pulse in the anastomosis (water hammer), decreased thrill, insufficient development of AVF after the stenosis site, presence of a weak pulse after compression of the outgoing vein<sup>(15,23,30,32,34,35,37,40,43,50)</sup></li> </ul>
<p><b>AUSCULTATION:</b></p> <ul style="list-style-type: none"> <li>- Breath characteristics: Normal - continuous and low frequency; and abnormal (sign of stenosis or inadequate maturation) discontinuous, high frequency, little or inaudible<sup>(10,14,25-28,30-33,38,39,41,42,45,46,48,50-52,57)</sup></li> <li>- Theft syndrome sign: AVF can have a very strong murmur<sup>(14)</sup></li> <li>- High output heart failure: intense and continuous murmur along the vein to the beginning of the arm and precordial region<sup>(48)</sup></li> </ul>

BMI - Body Mass Index; CKD - Chronic Kidney Disease

4<sup>th</sup> week<sup>(45)</sup>; within the first two weeks;<sup>(38)</sup> after two weeks;<sup>(47,49)</sup> after four weeks;<sup>(28,51)</sup> within six weeks;<sup>(32)</sup> three to six weeks<sup>(25)</sup> were other patterns evidenced. However, the majority indicated maturation assessment within four to six weeks.<sup>(10,14,15,26,31,35,37,43,52)</sup>

There were also studies showing times longer than six weeks: between four and eight weeks;<sup>(56,57)</sup> within two months after the procedure;<sup>(40)</sup> up to two to three months;<sup>(33)</sup> within four months;<sup>(29)</sup> in six months;<sup>(54)</sup> and another who recommended carrying out the assessment in two weeks, six weeks, three months, six months and 12 months of the postoperative period.<sup>(53)</sup>

Among the clinical assessment techniques, 23 studies (60.5%) recommended physical examination and 15 (39.5%) the combination of medical history and physical examination. The clinical elements flagged as necessary to assess maturation are summarized in Chart 3.

## Discussion

The results indicated a diversity of assessment elements for monitoring AVF maturation, with a predominance of physical examination as an assessment strategy.

The accuracy of the physical examination in assessing AVF maturation when compared to the DUS<sup>(28,29)</sup> converges with the findings of a study with patients from a radiology unit; physical examination exceeded DUS to diagnose stenosis (62% versus 58% detection).<sup>(18)</sup> According to COFEN (*Conselho Federal de Enfermagem* – Federal Nursing Council) Resolution 358/2009, which provides with the Nursing Process stages, nurses must apply the Nursing Process in any environment that occurs in nursing care. Physical examination was the technique used in data collection, providing with clinical indicators of relevance for decision-making.

Particular conditions may indicate the need for continuing education of elements linked to semiotics. Among them is the auscultation of murmurs indicative of vessel stenosis, which may require proper use of the stethoscope for correct interpretation of the verified sounds.

Regarding medical history, different studies pointed to a focus on surgical data and patient characteristics regarding sociodemographic, clinical and lifestyle data.<sup>(15,35,38,44,49,51–53,56,57)</sup> The relevance of these data can be seen in a study that analyzed the association with information from patients who established AVF over the period of one year. There was an association of patients with advanced age, female, black, presenting comorbidities (cardiovascular disease, peripheral arterial disease, diabetes, patients hospitalized or in need of assistance), under hemodialysis for more than a year and using a smaller catheter or arteriovenous graft success rate in AVF maturation.<sup>(12)</sup>

Furthermore, the data investigated in the medical history must be comprehensive and categorized into human factors such as advanced age and sex; factors related to blood markers such as coagulation disorders, use of anticoagulants, dyslipidemia, uremia and hypoalbuminemia; lifestyle and associated comorbidities, such as diabetes, hypertension, peripheral vascular disease, smoking and obesity;<sup>(4)</sup> in addition to other factors more directly linked to the fistula, such as endothelial dysfunction, vein diameter and dialysis patients with CVC.<sup>(58)</sup>

It was identified in the studies analyzed that AVF assessment, through physical examination, should be structured in inspection, palpation and auscultation, which when properly combined, constitute a fundamental part in caring for patients with vascular access. This combination produces crucial information that guides the detection of problems and the timely execution of interventions that prevent serious complications, potential loss of access and poor results.<sup>(59)</sup>

Inspection elements were highlighted in most studies with dozens of criteria indicated. The information from this stage can be important in detecting problems such as infections, aneurysms, bleed-

ing, venous and central segment strictures and theft syndrome.<sup>(16,59)</sup>

Palpation was the only step in the physical examination present in all studies, with most of them indicating that assessments through palpation should be directed to interpreting blood flow data, changes in diameter such as stenosis of the vessel lumen and checking for signs infection. Auscultation was also described in 21 analyzed studies (55.2%), aimed at assessing the characteristics of the murmur. These two steps are useful to confirm the findings of the inspection and provide with additional information, thrill, pulse and murmur being important elements for finding problems related to blood flow in the access.<sup>(16)</sup>

As for the period for postoperative assessment, the comprehensive variation indicates that there is no clear definition of the assessment period. This lack of convergence on the regularity of access monitoring may have the consequence of delaying the identification of problems in maturation, some of which are sometimes irreversible. This may require new research initiatives with synthesis designs, such as meta-analyzes. A multicenter study to investigate the development of AVF over six weeks found that in one day AVF already reaches 50% of adequate blood flow, and in two weeks it already reaches the expected diameter and flow. It is suggested that the postoperative assessment begins as soon as AVF is established for early identification of maturation problems, enabling the planning of alternatives to establish access, reducing the dependence on CVC.<sup>(60)</sup>

A dialysis center in the Netherlands assessed the effects of a protocol for pre- and post-operative assessments of AVF maturation on success rates in access maturation through a case-control study. In group one, 72 AVF surgeries were performed, without implementing the established protocol. In group two, 74 surgeries were performed, with the implementation of the proposed post-operative assessment protocol: first, the patient was returned for access examination, suture removal and education one week after the procedure; subsequently, the patient underwent a physical examination to investigate signs of thrombosis or maturation fail-



ure during visits to the unit three times a week. The study showed that with the monitoring performed in group two, there was an increase in the success rate of accesses. Significantly higher primary and secondary permeability rates were achieved, with an increase in primary patency from 36% to 49% and in secondary patency from 47% to 70%, with a decrease in surgical interventions.<sup>(61)</sup> The results suggest that further studies should be conducted to confirm the hypothesis that the frequency of assessment improves the success and duration of accesses.

A study developed at an American dialysis center instituted a rapid conversion protocol from CVC to AVF. There was an assessment two weeks after the access was created, a new assessment after four weeks. If AVF did not show clinical signs of maturation, an ultrasound was performed on the same day, if possible. The assessment continued until AVF was used correctly, and as a result, 99% of the catheters were converted into arteriovenous access.<sup>(62)</sup>

In relation to the professional in charge of clinical assessment, the nurse was the most cited in the studies. Dialysis nurses maintain regular and frequent contact with patients with AVF; therefore, they are the appropriate professionals to perform assessment using physical examination.<sup>(9)</sup> A study developed with 212 patients in two dialysis centers found that with the establishment of a protocol implemented by nurses, supported by the multidisciplinary team, the rate of use of AVF increased from 45.0% to 64.3% and the use of catheters decreased from 11.0% to 6.0%.<sup>(63)</sup>

Professional training is an important component for recognizing potential incidents during maturation and other stages of the process. The professional's specific experience in conducting the clinical assessment is relevant, and in the absence of an experienced examiner available, it is preferable to refer the patient to perform DUS.<sup>(16)</sup> Despite this, physical examination can be easily taught to health-care professionals in a short period of time.<sup>(24,30,54)</sup> However, years of professional experience in general should not be presumptive criteria for the quality of monitoring. Training should always be focused on the relevant elements of assessment, in order to guarantee a better monitoring result.<sup>(9,17)</sup>

Despite the predominance of assessments by nursing professionals, the studies did not report a comprehensive perspective guided by the Nursing Process, theory or nursing classification system. It is understood that this perspective can provide with support for care and contribute to the scientific strengthening of nursing. All stages of the process should be considered, in order to promote the quality of life of CKD patients undergoing hemodialysis.<sup>(64)</sup>

Limitations are the fact that the findings are derived from a large number of studies with more than ten years of publication, which leads us to reflect on the need for current studies on the subject; the possibility that studies published in other languages have been disregarded; and also the quality of the studies has not been assessed as is the case with systematic reviews. However, in the case of a production mapping review, these limits are unavoidable, and do not produce problems of interpretation in relation to the research objectives.

## Conclusion

This review mapped evidence that highlighted professional nurses as the most frequent evaluators of AVF; however, systematization of physical examination is still required through inspection, palpation and auscultation. Various assessment elements related to access permeability and vascular responses were presented. The predominance at the international level of assessment by nurses was also reported, and the relevance of professional training for an accurate interpretation of maturation. However, absence of a more comprehensive assessment approach guided by the Nursing Process and Theories and Standardized Languages is highlighted. This may indicate a new field of research and development of knowledge in the area. Furthermore, it is estimated that the best option is incorporating theories, Nursing Process and standardized terminologies of the profession, in addition to constructing and validating protocols for postoperative follow-up of patients with AVF. Therefore, one can guarantee the disciplinary focus of nursing in the assessment.

Even so, contribute to the patient's survival, whose access is vital for their treatment. For nurses' work, an accurate assessment implies more specialized and safe attention; for managers, it implies minimizing the costs of care and dispersing the workload of professionals, and possibly contributing to the health system, with a reduction in complications resulting from access to hemodialysis and a decrease in pressures on the care system as a whole.

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