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REVIEW

What do we know about flushing for intravenous catheter maintenance in hospitalized adults?

O que sabemos sobre o flushing para a manutenção de cateteres intravenosos em adultos hospitalizados?

¿Qué sabemos sobre el flushing para el mantenimiento del catéter intravenoso en adultos hospitalizados?

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ABSTRACT

Objective: to evidence the use of flushing to prevent complications from intravenous therapy. **Methods:** an integrative review in databases, using descriptors and selection criteria. Data were collected in 12 articles using an instrument and later classified, summarized and aggregated for knowledge synthesis. **Results:** it was evident that: the pre-filled syringe resulted in a lower occurrence of catheter obstruction; irregular flushing frequency caused advanced phlebitis; the use of Venous Arterial Blood Management Protection (VAMP) generated a lower incidence of blood infection; heparinized solution did not result in a lower central catheter failure rate; flushing volume and frequency were not predictors of catheter failure; flushing practice was not shown to be incorporated among professionals. **Conclusion:** there are disagreements about the volume, frequency, solution and devices used in flushing. New technologies can reduce complications such as obstruction and infection.
Descriptors: Advanced Practice Nursing; Catheterization; Medication Errors; Biomedical Technology; Infusions, Intravenous.

RESUMO

Objetivo: buscar evidências sobre o uso do *flushing* para prevenir a ocorrência de complicações na terapia intravenosa. **Métodos:** revisão integrativa em bases de dados, com emprego de descritores e critérios de seleção. Os dados foram coletados em 12 artigos com utilização de instrumento e, posteriormente, classificados, sumarizados e agregados para síntese do conhecimento. **Resultados:** evidenciou-se que: a seringa pré-carregada resultou na menor ocorrência de obstrução do cateter; a frequência irregular do *flushing* ocasionou flebite avançada; o uso do dispositivo *Venous Arterial Blood Management Protection* (VAMP) gerou menor incidência de infecção sanguínea; a solução heparinizada não resultou em menor taxa de falha do cateter central; o volume e frequência do *flushing* não foram preditores de falha do cateter; a prática do *flushing* não se mostrou incorporada entre os profissionais. **Conclusão:** há divergências sobre o volume, frequência, solução e dispositivos utilizados no *flushing*. Novas tecnologias podem reduzir complicações, como obstrução e infecção.
Descritores: Enfermagem; Cuidados de Enfermagem; Obstrução do Cateter; Dispositivos de Acesso Vascular; Segurança do Paciente.

RESUMEN

Objetivo: buscar evidencia sobre el uso del flushing para prevenir complicaciones en la terapia intravenosa. **Métodos:** revisión integradora de bases de datos, utilizando descriptores y criterios de selección. Los datos se recolectaron de 12 artículos utilizando un instrumento y, posteriormente, se clasificaron, resumieron y agregaron para la síntesis de conocimientos. **Resultados:** se evidenció que: la jeringa precargada resultó en la menor incidencia de obstrucción del catéter; la frecuencia irregular del flushing causaba flebitis avanzada; el uso del dispositivo de Venous Arterial Blood Management Protection (VAMP) resultó en una menor incidencia de infecciones sanguíneas; la solución heparinizada no dio como resultado una tasa de falla del catéter central más baja; el volumen y la frecuencia del flushing no fueron predictores de falla del catéter; no se demostró que la práctica del flushing se incorpore entre los profesionales. **Conclusión:** existen desacuerdos sobre el volumen, la frecuencia, la solución y los dispositivos utilizados en el flushing. Las nuevas tecnologías pueden reducir complicaciones como la obstrucción y la infección.
Descriptores: Enfermería; Atención de Enfermería; Obstrucción del Catéter; Dispositivos de Acceso Vascular; Seguridad del Paciente.

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INTRODUCTION

Flushing is the manual injection of 0.9% sodium chloride (0.9% SF) performed in a peripheral or central venous catheter in order to clean the catheter, assess its functioning and prevent complications. Good flushing practices are essential to maintain catheter patency with a flow similar to that of the vein profile, preventing occlusion from blood accumulation and other products on the internal surface of the catheter, in addition to removing fibrin deposits from the lumen and preventing interactions due to fluid/drug incompatibility[1-3].

These good flushing practices have been established through guidelines based on scientific evidence, which aim to promote safe and effective care practice. Currently, at the national level, the guidelines of the Brazilian National Health Regulatory Agency (ANVISA - *Agência Nacional de Vigilância Sanitária*) and, internationally, of the Infusion Nurses Society (INS) stand out, which have guided care related to flushing. In this sense, these guidelines recommend the assessment of blood reflux before each infusion and the application of the flushing technique according to the SAS order, before and after the administration of each drug, namely: 0.9% SF injection (S), followed by medication or fluid administration (A) and, finally, the flushing of SF at 0.9% (S)[2,4-5].

The procedure for maintaining catheter patency is a care responsibility of the nursing team, for which it is necessary to have knowledge and competence, requirements that allow it to prevent failures, notify errors and promote the safety and well-being of patients who use medications intravenously[6]. National and international studies show results indicating a variability in the practice of flushing, pointing out difficulties of nursing professionals in its implementation[7-12].

In the case of studies related to peripheral venous catheters (PVC), in a cohort investigation that assessed the incidence of obstruction in patients hospitalized in a medical clinic in Portugal and the use of flushing to prevent obstructions, the authors followed the care performed by nurses in intermittent medication administration from their preparation. The incidence of obstruction was 50%, and flushing was a care adopted by nurses to prevent obstruction, but there was no uniformity, as in most circumstances it was used before to assess catheter patency and, in others, before or after the drug. As for volume, infusions of 3, 5 and 10 ml of 0.9% normal solution[7] were adopted.

In central venous catheters (CVC), research that sought to understand flushing practices among American intensive care nurses showed that, of the 632 survey respondents, 64.6% used normal solution, 31%, a combination of normal solution with heparin, 4.4%, only heparin, and 0.5%, alteplase. The most common volumes were 10 ml for normal solution and 3 ml for heparin, with variation in heparin concentration. The authors concluded that central catheter flushing practices vary widely[8].

Regarding the way to prepare for flushing, studies show that syringes pre-filled with normal solution are associated with an increase in catheter permanence time, reduction in the time needed to prepare for flushing and the risk of contamination of the device or solution, maintenance positive pressure during lavage, in addition to the potential to help promote adherence to clinical protocols and guidelines for flushing[9-10]. However, in many institutions, the solution to perform flushing still requires prior preparation, involving the consumption of aspiration needle, syringes and solution ampoules[11].

As for the flushing technique, in a review of pulsatile flushing, the authors stated that this technique is more efficient than continuous flushing. Practice relies on fluid flow dynamics, i.e., wall shear stress, which is more efficient in cleaning up solid deposits in catheters compared to 10 ml continuous flow[12]. More recently, an experiment carried out in the laboratory with rabbits assessed the effect of different flushing methods on blood vessels: pulsatile flow, continuous flow and no treatment. In the end, it was shown that continuous flow was superior to the pulsatile one, as it produced less damage to endothelium and adjacent tissues, but it is more subject to thrombosis. The authors suggested the need to assess patients' vascular conditions before choosing the flushing method[13].

These data on the volume, the solution used, the form of preparation and the technique used indicate a lack of knowledge about flushing. In turn, inadequate catheter maintenance practices lead to obstruction, characterized by occlusion of the lumen due to blood clot formation or drug precipitate. Signs of catheter obstruction are infusion interruption, infusion pump's occlusion alarm activation and slow flow[5]. Its frequency varies, on average, from 15 to 66% for CVC and from 20 to 69% for PVC, depending on the device and population[9].

Several studies have pointed out the occurrence of obstruction in venous catheters as an outcome that compromises patient safety[14-15]. An example is the study that determined the incidence of adverse events related to PVC during its stay and removal from the assessment of 815 catheters in 573 patients hospitalized in clinical and surgical wards in France. The incidence of adverse events was 52.3/100 catheters, with emphasis on phlebitis, hematoma and extravasation. The most frequent mechanical adverse event was catheter obstruction, with an incidence of 12.4/100 catheters[14].

In addition to interruption of intravenous therapy, obstruction causes pain associated with device flow resistance, risk of infection, as clotted blood can be a culture medium, catheter-related thrombosis, in addition to increased medical care costs due to the expense of resources in the exchange of devices and care team time[1,3].

Given the high degree of variation in the practice of maintaining permeability of peripheral and central venous devices observed in research on the subject in question[1,3,7-12], which indicate the need for more evidence on volume, technique and regime to be applied as well as on the effects of flushing in complications prevention; this proposal for a review is justified, in order to contribute with knowledge that sustains professional practice.

OBJECTIVE

To seek evidence on the use of flushing to prevent complications from intravenous therapy.

METHOD

Study design

This is an integrative literature review, method chosen because it allows the synthesis of multiple studies published, in

this case, on flushing, and allows general conclusions about a theme, knowledge that in the research under consideration has a potential contribution to nursing practice. It was developed in six steps: theme identification and research question selection for the review; establishment of criteria for inclusion and exclusion of studies/sampling or literature search; definition of information to be extracted from selected studies/categorization of studies; assessment of studies included in the integrative review; interpretation of results; and presentation of review/synthesis of knowledge[16]. The PRISMA tool support was used for the study development[17].

Methodological procedures

Literature search for inclusion/exclusion of studies was carried out in international databases: National Library of Medicine (MEDLINE via PubMed), Cochrane, Cumulative Index to Nursing and Allied Health Literature (CINAHL) via EBSCOhost, Spanish Bibliographic Index of Health Sciences (IBECS - *Índice Bibliográfico Español en Ciencias de la Salud*), Embase, and in the Literature of Latin America and the Caribbean (LILACS), through the Coordination Portal for the Improvement of Higher Education Personnel (CAPES - *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*).

From the identification of the need for synthesis of knowledge, considering the divergences about flushing practice among nursing professionals and its effects on maintaining catheter permeability, the question that guided the review, the first step of the method, was elaborated through PICO mnemonic: what has been discussed in literature about flushing practice to maintain the permeability of intravenous catheters (phenomenon of interest) used in adult patients (population) hospitalized (context)?

The research data source was scientific articles. The terms used to search the databases were selected from CINAHL Headings, Medical Subject Headings (MeSH) as MeSH terms and All Fields, and from Health Sciences Descriptors (DeCS) as descriptors and keywords. The descriptors listed were: Vascular Access Devices, Central Venous Catheters, Peripheral Catheterization, Degree of Vascular Clearance and Catheter Obstruction. In crossing the descriptors, Boolean operators AND and OR were used, aiming to obtain as many articles as possible to answer the guiding question.

The base survey was carried out in January and February 2021. The strategy used in MEDLINE (via PubMed) is presented in Chart 1, as an illustration of how the search process for scientific articles took place. The words and terms included were combined in a single search strategy, adapted according to the specificities of each database used in the review.

For selection, the second stage of this review, articles from original research and systematic reviews published between 2016 and 2020 were included. This five-year cut-off was established because it is the year of updating the internationally recognized recommendations and guidelines for nursing practice: Standards for Infusion Therapy from the Royal College of Nursing and Infusion Therapy Standards of Practice from the Infusion Nurses Society; with full text available; in Portuguese, English and Spanish; that dealt with venous catheters, addressing flushing intervention in catheter maintenance. Articles dealing with the pediatric and neonatal population, which referred to the use of a catheter in an outpatient and home environment, use of catheter for functions other than drug infusion, articles that dealt with hemodialysis venous catheters, were excluded.

Chart 1 – Search for articles performed in MEDLINE (via PubMed), Brazil, 2021

Search	Number of finds found
((“Vascular Patency”[MeSH Terms]) OR (“Catheter Obstruction”[MeSH Terms]) OR (flush[Title/Abstract]) OR (flushes[Title/Abstract]) OR (flushing[Title/Abstract]) OR (irrigation[Title/Abstract]) OR (irrigations[Title/Abstract]) OR (patency[Title/Abstract]) OR (obstruction[Title/Abstract]) OR (obstructions[Title/Abstract]) OR (clearing[Title/Abstract]) OR (clearings[Title/Abstract]) OR (occlusion[Title/Abstract]) OR (occlusions[Title/Abstract])) AND ((Catheters[MeSH Terms]) OR (“Vascular Access Devices”[MeSH Terms]) OR (“Central Venous Catheters”[MeSH Terms]) OR (“Catheterization, Peripheral”[MeSH Terms]) OR (catheters[Title/Abstract]) OR (catheter[Title/Abstract]) OR (lines[Title/Abstract]) OR (line[Title/Abstract]) OR (“vascular access”[Title/Abstract]) OR (“vascular accesses”[Title/Abstract]))	6,332

In the selection process, after crossing the descriptors and keywords in each chosen database, the initial filters of “full text”, such as “article”, “language” and “time frame”, were applied. Then, with the help of Mendeley, duplicate references were excluded. After this step, the articles found were submitted to an exploratory reading of title and/or abstract. Those considered adherent to the theme were pre-selected for the later phase, of reading the content in its entirety. In assessing the full text, articles were classified into eligible or ineligible. Eligible were those articles whose content referred to characteristics related to flushing, such as technique, type of solution, volume, times of use (before, between, after medication administration). Those classified as ineligible were those who did not refer to hospitalized adult patients and did not refer to the use of a catheter for administering medication.

Data collection, organization, and analysis

The 3rd phase of this review was to collect data from previously selected articles. Data extraction was performed using an instrument developed by the authors that contained information on year of publication and country of study, methodological design used, sample, study objective, results found, and recommendations and/or conclusions. After these data were collected, they were summarized with the adoption of a synoptic table, in which the main information related to the research question was gathered. The included studies received code S = Study, followed by the Arabic number according to the order of capture.

The 4th phase was the critical analysis of included studies, which considered the quality of the information collected in the studies, in order to understand the problem presented and answer the outlined research question. Thus, the previously organized data were categorized in relation to flushing characteristics (technique, volume, regimen, preparation) and its effects on catheter patency maintenance, as well as in relation to flushing implementation in clinical practice, from which it was the aggregation of data was done and the intended knowledge synthesis was carried out.

After the presentation of results regarding this synthesis, they were discussed in the fifth phase considering the existing literature on the subject, establishing interfaces with nursing practice and the concepts that support intravenous therapy safety for patients. This enabled the interpretation of results, the final product of this integrative review (sixth step). In the review development, ethical aspects regarding authors' rights were respected, with inclusion in the list of references of all works cited throughout the text.

RESULTS

In the searches in the databases, 29,894 articles were identified using the chosen strategy. In the first round of selection, studies that did not meet the criteria of year of publication, language and text format were excluded, which reduced the number to 8,794 studies. With the help of Mendeley, duplicate references (1,495) were excluded. Thus, 7,190 studies were available for the next phase of selection. After the exploratory reading of title and abstract, 7,136 studies that did not show adherence to the research question were excluded, leaving 54 for analysis of full content.

Two reviewers performed the analytical reading of the 54 remaining studies in full, to verify the contribution of pre-selected articles in answering the study question. Disagreements between authors were discussed until a consensus was reached. After this stage, 42 studies were excluded because they referred to the pediatric population, catheter use in the home environment or catheter use for functions other than drug infusion. In the end, 12 studies constituted the research corpus and underwent interpretive reading. Figure 1 illustrates the selection flow.

Of the 12 articles found, the largest amount of research was carried out in Europe, with four studies, followed by Oceania with three. South America and Asia had two studies each, followed by North America and Africa with one study in each territory.

The articles were distributed throughout the research period (2016-2020), with the highest concentration (n=6/50%) in 2018, followed by 33% (n=4) of publications in the last two years, which highlights the discussion current practice. As for devices studied, 50% (n=6) were related to peripheral catheter, 33% (n=4) to central catheter and 17% (n=2) to peripherally inserted central catheter. The main information from the 12 studies on flushing was organized in Chart 2.

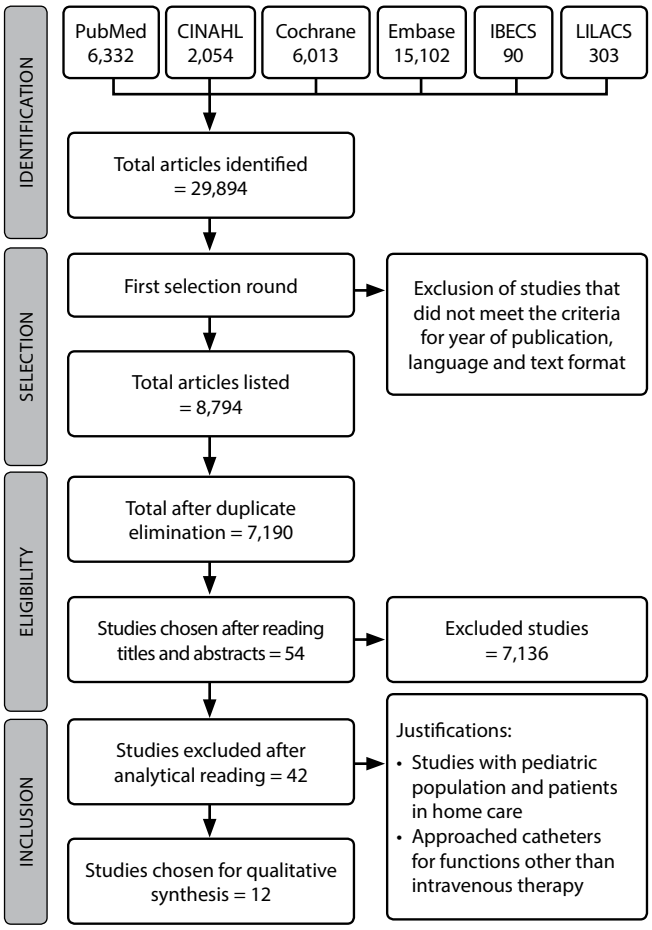

Figure 1 - Flow of selection of articles in databases, Brazil, 2021

The synthesis built after aggregating the results of the selected surveys indicated that current knowledge about flushing was organized into two synthesis units:

Chart 2 - Synoptic table of studies included in the review, Brazil, 2021

Study (S)	Title Year/Country Database	Methodological design/Sample	Objective	Results	Recommendations/ Conclusions
S1[18]	Varied flushing frequency and volume to prevent peripheral intravenous catheter failure: a pilot, factorial randomized controlled trial in adult medical-surgical hospital patients 2016/Australia CINAHL PubMed Cochrane Embase	Controlled randomized clinical trial n: 160 patients using PVC	Test the effect of varying volumes of solution and flushing frequencies on PVC failure.	Device failure rates per 1,000 hours were not significantly different for 3 ml and 10 ml volume intervention (p = 0.06). Regarding the frequency of 24 hours versus 6 hours (p = 0.05) for the interval for performing flushing in PVC without continuous perfusion, there was also no difference. The catheter handling rate per day (flushing combined with medication administration) significantly predicted peripheral catheter failure.	Increased volume and frequency of flushing did not significantly alter the risk of PVC failure. Being female, catheter insertion site on the dorsum of the hand and a greater number of episodes of access manipulation (for flushing and medication) increase the risk of PVC failure.

To be continued

Chart 2

Study (S)	Title Year/Country Database	Methodological design/Sample	Objective	Results	Recommendations/ Conclusions
S2[19]	Heparin versus normal saline: flushing effectiveness in managing Central Venous Catheters in patients undergoing Blood and marrow transplantation 2018/ USA CINAHL PubMed Cochrane	Controlled randomized clinical trial n: 30 patients chosen for convenience submitted to Bone Marrow Transplantation (BMT). Each patient with a new CVC was randomized to receive either heparinized solution or normal saline alone for washing.	Determine if there is a difference in line patency when using only normal saline versus heparin and saline and check the incidence of Central Venous Catheter-Associated Blood Stream Infection (CLABSI) when releasing central lines in patients undergoing BMT.	Among the 698 events observed, line problem rates were similar between washing with heparin and normal saline (8.8%) and with normal saline (8.5%) (p = 0.88). For patients with baseline problems, plasminogen activator was administered at similar rates for heparin flushing (25%) and flushing using normal saline (27%) (p = 0.02). A CLABSI occurred in the saline group, however it did not represent a deviation from the historical CLABSI rates of the study site.	The study did not show conclusive differences in heparin efficacy and safety with normal saline versus washing with normal saline only for CVC treatment, which requires caution, due to the risks of heparin.
S3[20]	*Práticas dos enfermeiros na cateterização intravenosa periférica: um estudo descritivo* 2019/ Portugal CINAHL	Cross-sectional and descriptive study n: observation of 26 nurses during insertion of 38 catheters and 66 times of PVC maintenance	Know nurses' practice during PVC insertion and maintenance	Regarding PVC maintenance, nurses tested catheter patency using 0.9% sodium chloride for flushing (78.8%) and 21.2% of participants did not verify catheter patency before administering intravenous medication. There was a variation in the volume and technique used for maintenance. In 35 cases, PVC was used to administer medication intravenously, occurring multiple administrations in 15 patients. Overall, PVC flushing was performed between multiple medication administration in 53.3% of the moments observed, while in one fifth of the cases a final flushing moment was not performed.	Nursing practices during PVC insertion and maintenance are not consistent and do not always respect current standards of care recommendations.
S4[21]	Best practices in the management of central vascular access devices: an observational study in areas with a high prevalence of trained nurses (2018)/Italy CINAHL PubMed Embase	Observational study n:148 nurses from nine medical-surgical wards; 171 observations (53 dressing procedures and 118 flushing procedures).	Determine the level of good practice in areas with a high prevalence of nurses trained in the management of central vascular access devices.	Of the 118 flushing procedures observed, 76% were performed in accordance with good practices. The most frequent errors were related to incorrect use of needleless connectors. Thirteen of 28 incorrect procedures (46%) involved failure to disinfect needleless connectors. Specifically regarding flushing, there were no considerable differences between nurses who participated in the course and those who did not.	Overall, the variables that influenced the best management practices for central vascular access devices were related to nurses with less than five years of professional experience and who recently participated in a training program.
S5[22]	Factors contributing to phlebitis among adult patients admitted in the medical-surgical units of a central hospital in Harare, Zimbabwe 2018/Zimbabwe CINAHL PubMed Embase	Quantitative, analytical study n: 46 hospitalized patients	Assess the factors that contribute to phlebitis after PVC insertion among adult patients admitted to the medical-surgical units of a Central Hospital in Harare, Zimbabwe.	The findings of this study showed that in no catheter was flushing performed as regularly as expected. Only 13.0% performed flushing, however, the practice took place irregularly according to INS guidelines; 72.7% of PVC that were never washed developed advanced stages of phlebitis (grades 4 and 5).	Among the contributing factors for phlebitis, irregularity in catheter flushing was highlighted. It was recommended that procedural guidelines on catheter maintenance care be disseminated at the study site.

To be continued

Chart 2

Study (S)	Title Year/Country Database	Methodological design/Sample	Objective	Results	Recommendations/ Conclusions
S6[23]	The flushing procedure in nursing practices: A cross-sectional study with Portuguese and Brazilian nurses 2020/Portugal and Brazil PubMed Embase	Cross-sectional and descriptive study n: 76 Brazilian and Portuguese nurses answered an online questionnaire.	Identify nursing practices related to flushing procedure in PVC, namely: times of performance; size of syringe used; the solution of choice, volume and technique applied; knowledge and compliance with the recommended rules on flushing by nurses.	Most nurses (84.2%) reported performing flushing. The most used technique was continuous pressure with the syringe plunger (31.2%), followed by the push-pause technique (23.4%). Although most perform flushing at four different times (after device insertion, before, between and after drug administration), there were inconsistencies in flushing solution, volume and syringe size. The volume most used for washing was 5 ml, filled with normal solution. There was recognition of the omission of this procedure due to time limitations, lack of familiarity with material procedure and unavailability.	The study concluded that flushing procedure is not always performed by nurses in their clinical approach. Moreover, several inconsistencies were observed between the practice developed by nurses in performing flushing, reflecting the lack of empirical evidence in this area of research.
S7[24]	Evaluation of a novel flushing protocol for a peripherally inserted central catheter (PICC) in the neurological intensive care unit: A prospective randomized study 2018/China PubMed Cochrane Embase	Prospective randomized clinical trial n: 360 patients from a neurointensive unit using PICC. The experimental group used the VAMP system (Closed system device with a 5 ml reservoir used to store 0.9% SF) for flushing. Control group: conventional method	Investigate whether a new flushing method using the VAMP system for PICC could decrease the risk of venous thromboembolism and bloodstream infections compared to the traditional flushing method.	The occurrence of infection and mean time to perform flushing were statistically lower in the experimental group (VAMP). The PICC occlusion rate, proportion of males, age, APACHE II score and length of hospital stay did not show significant differences between the two groups.	The VAMP system as a method for flushing is simple to use and may be more beneficial for patients with PICC, as it allows for a decrease in the risk of infections related to the bloodstream.
S8[25]	Effect of a patency bundle on central venous catheter complications among hospitalized adult patients: a best practice implementation project 2018/Australia CINAHL PubMed Embase	Observational, quantitative n: 20 nurses in two Intensive Care Units	Improve continuity of care, reducing central catheter occlusions from training to apply a bundle of good practices in CVC maintenance.	In a preliminary observation, the selection of appropriate syringe size (100%), flushing volume (80%), solution and sequence (90%) was rated as excellent. Nurses' compliance with the aspiration and assessment of blood return (40%) and the use of the push-pause technique (25%) were insufficient and exposed a significant knowledge gap and need for education. After performing a multimodal education model, there was a significant improvement in nurses' flushing technique. Twice as many nurses remembered to aspirate for blood return and apply the push-pause technique. However, catheter patency/occlusion documentation did not improve.	Multimodal education reached all nurses and contributed to significantly improve compliance with best maintenance practices. Nurses were trained to solve occlusion problems using thrombolytics. However, after three months of multimodal training the data did not demonstrate a continuous downward trend in occlusion rates.
S9[26]	Normal saline versus heparin for patency of central venous catheters in adult patients - a systematic review and meta-analysis 2017/China PubMed Embase	Systematic review with meta-analysis n: 10 clinical trials involving 7,875 individuals	Assess the effectiveness of normal saline (NS) versus heparinized solution (HS) in maintaining CVC permeability in adult patients.	NS can be equally, if not more effective, in keeping CVC functioning. Of the studies that reported secondary outcomes (heparin-induced thrombocytopenia, hemorrhage, central venous thrombosis, and catheter-related bloodstream infection), heparinized saline was not shown to be superior to non-HS. However, in short-term use (<30 days), flushing with HS is slightly superior to NS.	HS is not superior to NS in reducing CVC occlusion. However, in the short term, the use of HS is slightly superior to NS for flushing catheters, from a statistical point of view.

To be continued

Chart 2 (concluded)

Study (S)	Title Year/Country Database	Methodological design/Sample	Objective	Results	Recommendations/ Conclusions
S10[27]	The impact of flushing with pre-filled saline syringes on the incidence of PVC failure: A quasi-experimental study (2019)/Spain PubMed Embase	Quasi-experimental design, before and after intervention study. n:3,853 PVC in 1,915 patients analyzed.	Demonstrate the differences in overall PVC failure rates before and after the introduction of pre-filled saline syringes for flushing.	Compared with the pre-intervention period, a significant decrease in the PVC failure rate was observed in the intervention period (57% vs 43.4%, p<0.001).	The use of saline pre-filled syringes significantly reduced PVC failure and increased catheter dwell time. It was concluded that the use of pre-filled syringes is important to perform flushing and to reduce the incidence of PVC failure.
S11[28]	Management of peripherally inserted central catheter use in an intensive care unit of a teaching hospital in Brazil: a best practice implementation project 2018/Brazil PubMed	Evidence implementation project with pre- and post-test n: pre: 22 patients and 180 nursing staff. After an educational program: 14 patients and 180 nursing staff	Conduct an audit to assess compliance with best practices in PICC management in the Intensive Care Unit and implementation of evidence-based practices recommended by the Joanna Briggs Institute (JBI)	The initial audit indicated that PICC maintenance in relation to flushing had low compliance of 2 to 20%, especially for the criteria related to PICC permeability assessment with a 10 ml syringe or carrying out before and after drug administration, blood product infusion, lipid infusion and blood collection. After the implementation of best practices by JBI for PICC management, a new follow-up audit was carried out, which showed improvement in all 10 criteria. Criteria related to flushing achieved 83% to 89% compliance.	Greater compliance with evidence-based best practices was achieved on all audit criteria assessed after an educational program The criteria that achieved the greatest compliance with best practice recommendations were related to prevention of bloodstream infection and PICC loss due to obstruction.
S12[29]	Implementation and evaluation of short peripheral intravenous catheter flushing guidelines: a stepped wedge cluster randomized trial 2020/Australia PubMed Embase	Cross-sectional, randomized, cluster study n: 619 patients (control n = 306, intervention n = 313)	Assess the effect of a bundle to enforce PVC flushing guidelines with pre-filled flush syringes.	Practice in the control group was standard treatment (variable practice with manually prepared flushing with 0.9% sodium chloride). The intervention group received practice guidance on bundled reinforcement education (including administration with a pre-filled syringe prepared by the manufacturer). PVC failure was 91 (30%) in the control and 69 (22%) in the intervention group. Total costs were lower in the intervention group. No serious adverse events related to the study intervention occurred.	This study demonstrated the effectiveness and lower cost of flushing PVC with a pre-filled syringe according to recommended guidelines. Evidence-based education, use of bundles, surveillance, and post-PVC maintenance materials are vital to improving patient outcomes.

1) Flushing - volume, regimen, solution, preparation and technique: effects on complication occurrence in intravenous therapy

Regarding PVC, the volume and interval during flushing did not interfere in obstruction occurrence, on the other hand, the greater number of PVC manipulations throughout the day was a predictor of its failure (S1[18]); negligence or irregular performance of flushing generated an advanced stage of phlebitis in patients using PVC (S5[22]); flushing preparation with pre-filled syringes significantly reduced obstruction occurrence, with increased catheter dwell time and related costs reduction (S10[27]; S12[29]).

With regard to CVC, the studies reiterated the absence of differences between the HS and the NS for the maintenance of these devices in the event of catheter failure (S2[19] and S9[26]); the laminar flow flushing technique using the VAMP system in patients with PICC was effective and prevented greater bloodstream infection compared to the traditional flushing method (S7[24]).

2) Flushing implementation in clinical practice by the nursing team: characteristics, associated factors and interventions for improvement

Regarding flushing implementation, nursing practices in PVC maintenance showed inconsistencies and did not always respect the current recommendations of good practices (S3[20]; S5[22]; S6[23]). The lack of guidelines/protocols on catheter care and flushing, which implied negligence and failures in practice (S5[22]), professional experience <5 years, and recent participation in training programs were positively associated factors in flushing practice by the nursing staff in CVC (S4[21]).

Studies involving PVC, CVC and PICC showed that the nursing staff's education/training generated positive results in intravenous device maintenance (S8[25]; S11[28]; S12[29]). The implemented practices that generate improvements were multimodal education carried out at the best times for the nursing staff, the use of bundles based on best scientific evidence in line with training on

flushing practice, and internal audits to monitor safety indicators in intravenous therapy.

DISCUSSION

Data from studies that integrated the corpus of this review reiterated the relevance of flushing procedure in intravenous catheter maintenance, as well as its role in preventing complications related to intravenous therapy, an aspect that is in line with other investigations on this topic[7,30].

One of the results obtained was on flushing volume, which did not show differences in the use of 3 or 10 ml in obstruction occurrence in PVC. At this point, INS recommends using a minimum volume of flushing solution equal to twice the internal volume of the catheter system, i.e., the catheter with additional devices[5]. This translates to 3-5 ml for a CVP and 10 ml for a CVC, increasing to 20 ml after blood draw or flushing after vesicant medication administration. Furthermore, factors should be considered when choosing the flushing volume, which include catheter type and size, patients' age and the type of intravenous therapy to be administered[1-4].

Our finding on the differences in flushing practice in relation to volume corroborates the literature, according to which there is currently no standardization of flushing practices, which may result from the lack of evidence to indicate the right volume to be used[7,9]. This lack of standardization is illustrated in research on this topic[9,31-32].

A study analyzed the frequency, type and volume of flushing used in PVC by 35 nurses who worked in medical-surgical sectors of an academic hospital in the USA. Nurses received a form in which they should record four flushes performed during their work shift, specifying the type of flushing, the time and the volume used. Furthermore, at the end of the shift, they needed to define catheter status, whether it was patent, occluded, infiltrated, removed or otherwise. A total of 538 flushes were recorded, most categorized as catheter maintenance type. The volumes of flushes documented on the forms indicated that they ranged from 02 to 10 ml, more frequently to 10 ml. The analysis of the association of flushing frequency and volume with catheter status at the end of the shift indicated a positive relationship, i.e., the pervious catheters were those that received flushing with the highest frequency and volume[31].

The survey on flushing practice, Australian nurses analyzed the responses to 1,178 questionnaires, of which 1,028 referred to handling PVC, and, 584, CVC. The 10 ml syringe was used by most respondents who handled peripheral (75%) and central (82%) catheters. The number of participants who reported using syringes with a volume of less than 10 ml was higher among those who handled the peripheral catheter (24%). The use of pre-filled syringes in both groups was around 10%. The 10 ml volume was the most common among respondents both in the peripheral and central catheters, followed by the 5 ml volume. Flushing frequency varied, with the most common times being before and after medication (23% of PVC and 21% of CVC), and before and after and after 6 hours of medication administration (23% of PVC and 21% of CVC). The study concluded that there was an inconsistency in practices and indicated that the volume and interval for performing flushing require further investigation[9].

An observational study also assessed the practice of administering intravenous medication (preparation, administration and documentation) and performing flushing in PVC by nurses from a clinical-surgical area, comparing this practice with the institutional policy recommendations. Regarding medication administration, 28 (34%) were in bolus, 33 (44%) were in bags (solution bags) and 18 (22%) were through burettes. In the case of bolus medications, 86% of them had flushing before and after; in bags, most of 100 ml of solution, in 100% of administrations flushing did not occur before and after; and in burettes, in 100% there was no flushing before and in 72% there was no after. When performed, the volume of 10 ml was mostly used. This result reinforced the need for continuous actions for attitudinal changes of professionals, since flushing to maintain catheter patency and prevent mixing of incompatible solutions should be used regardless of the form of medication administration[32].

These investigations to support the discussion show, in addition to differences in relation to the volume used, failures in flushing practice regarding its times and frequency, as well as the correlation of such failures with complication occurrence, an aspect also pointed out by one of the studies in our review[22], in which the neglect of flushing practice in PVC resulted in advanced degrees of phlebitis.

The formation of thrombi or phlebitis, as well as microbial proliferation at the PVC insertion site can trigger nosocomial infections that, consequently, increase patient length of stay and costs associated with treatment and mortality[10]. These complications also influence patients' well-being, particularly at the psychological level, since it requires a new venipuncture procedure, which has the potential to increase the levels of anxiety, stress and pain felt by patients[33].

In two studies included in this review, the use of pre-filled syringes significantly reduced PVC failures and complication occurrence, increased the length of dwell of this device and reduced related costs[27,29]. It is pointed out that pre-filled syringes are marketed in order to minimize the incorrect choice of syringe size and solution to be used. They are produced in a diameter of 10 ml, with volumes of 3, 5 and 10 ml of NS to be administered according to catheter[9].

Our results on the pre-filled syringe are in line with those of other investigations, which point to the positive clinical and financial impacts of incorporating this technology[34-35]. An economic assessment study showed that the use of a pre-filled syringe promoted a 77% and 62% reduction in bloodstream infection occurrence associated with the catheter and occlusion, respectively, compared to the manual filling syringe. The cost per flushing was R$ 32.88 (about US$6.00) for the pre-filled syringe and R$ 98.48 (about US$19.00) for the manually filled syringe, with a percentage cost reduction of 67%. Thus, the pre-filled syringe proved to be the most cost-effective option for flushing in patients with CVC[34].

Research that compared the use of filled syringes with those prepared manually for flushing in fully implanted CVC in adult cancer patients retrospectively assessed 269 catheters perfused with manually prepared syringes and 449 with pre-filled syringes. The rate of catheter removal due to complications was similar in both groups, and the incidence of catheter-related blood infection was higher in the manually prepared syringe group. The applied statistical analysis confirmed the association between pre-filled syringe and the reduction of blood infection[35].

It is noteworthy that more recent studies have pointed out new technologies aimed at improving adherence to flushing practice[36-37]. One of them is the development of a double chamber syringe to allow medication administration and flushing from the

same syringe. This revealed an important step to facilitate the adoption of good clinical practices in intravenous procedures, reducing catheter manipulations by nurses[36].

Our review did not find the superiority of HS over the NS for flushing in occlusion prevention in CVC[19,26], a result that is consistent with the INS recommendation regarding the use of 0.9% SF in preventing catheter occlusion in adult populations, both in CVC and PVC[2,5], as well as with the findings of other reviews already carried out[38-39].

A systematic review assessing the efficacy of intermittent locking (maintaining catheter patency while not in use) of CVC with heparin versus NS to prevent occlusion analyzed 11 clinical trials involving 2,392 participants. The authors pointed out differences in the surveys regarding heparin dose, catheter follow-up length and unit of analysis (participant, catheter or access line). The combined results of 10 clinical trials involving 1,672 participants revealed fewer occlusions with heparin compared to saline. However, the evidence was of low quality[38].

Therefore, it was concluded that the smallest number of intermittent locking occlusions with heparin compared to NS is uncertain. The low quality of evidence suggested that heparin may have little or no effect on catheter permeability[38]. In peripheral catheters, a systematic review with meta-analysis also corroborated the indication of the main guidelines that the use of normal NS seems to outperform HS in maintaining CVP permeability and complication prevention[39].

Regarding the flushing technique, one of the studies highlighted the efficacy of the alternative technique using the VAMP closed system in PICC[24]. In this technique, flushing applied with continuous flow with positive pressure from a device with a 5 ml reservoir was more effective in preventing infection compared to the traditional method, which involved disconnection of the system for flushing with a 10 ml syringe.

In South Korea, a device coupled to the equipment flow controller was created for flushing to be performed by sliding this device along the equipment, thus promoting catheter cleaning. This innovative technology showed greater efficacy, safety and convenience compared to the conventional flushing method, and there were no complications related to the intravenous device, including occlusion[37].

It should be noted that the INS and ANVISA indicate the use of the pulsatile technique as a good flushing practice[2,4-5]. The pulsatile technique generates an unstable flow that significantly reduces solid deposits when compared to flushing with laminar flow[1-3]. Furthermore, not only the type of flow, but also the time interval between two bolus. Ten short bolus of 1 ml solution interrupted by brief pauses may be more effective in removing fibrin, drug precipitate, intraluminal bacteria compared to low continuous flow techniques[5].

Our results from synthesis unit 2 showed that professional experience less than five years and participation in training programs were positively associated with flushing, while the lack of guidelines/protocols on catheter care resulted in negligence and failures in flushing.

This result on the experience was different from a study that explored the factors that influenced CVP maintenance care, in which the flushes recorded by nurses during their work shift were analyzed as well as nurses' discourses about this practice through focus group sessions[31]. The researchers found a linear relationship between years of experience and flushing frequency. Although the association was considered weak, an increase in the average number of flushes of 0.036 was identified for each additional year of experience. This quantitative data was in line with the qualitative data produced in the focus groups, in which participating nurses indicated that previous experiences of complications related to CVP and patient pain made them more attentive and cautious in CVP care[31].

This indicates that the variable experience deserves to be investigated in relation to flushing practice. Regarding knowledge about flushing guidelines and their influence on professionals' practices, it is considered that knowledge is essential in the management of vascular catheters, which implies access to education by professionals about catheter care and maintenance as well as access to clear and evidence-based guidelines that objectivize standardize practices[3].

Illustration of this is seen in evidence implementation research that aimed to identify current practice in relation to CVC maintenance, to improve knowledge among the nursing team and to assess the increased compliance with evidence-based best practices. The method included auditing through observation and analysis of medical records, followed by feedback. The pre-implementation phase of the educational program involved 22 patients and 180 nursing staff, and in the phase after 14 and 180, respectively[40].

The initial PICC management audit in relation to flushing was low-compliance, from 2 to 20%, while, in the follow-up audit, the criteria related to flushing reached 83% to 89% compliance. The criteria that achieved the greatest compliance with best practice recommendations were related to prevention of bloodstream infection and loss of the PICC due to obstruction[40].

This result indicates that the nursing team should be encouraged to keep up-to-date, with the development of strategies for their participation in continuing education programs, encouragement of behavior change, creation of a group of experts in the institutions, implementation of new technologies that favor the practice of flushing, development of protocols based on scientific evidence that can assist in procedures, in addition to informing patients about the importance of maintaining catheter patency[40-41].

Other factors with the potential to influence non-adherence to flushing include were as follows: time available to perform all nursing care; complexity and degree of dependence on patients; workload; number of nurses; existence of periodic assessment of quality indicators; and perception of a low priority activity. Such factors should be objects of analysis according to each reality considering the proposition of safety barriers that avoid medication errors related to flushing[7,31].

Study limitations

The cross-sectional methodological design of a portion of the studies included in the review is a limitation, considering the lower level of coverage of the results of this type of study in the generation of robust evidence on flushing practice by the nursing team.

Contributions to nursing

The results of this review disseminate the best nursing practices in relation to flushing, particularly with regard to procedure's characteristics and technologies used (solution, volume, devices, frequency), which helps to reduce the indicators of occurrence of complications during intravenous therapy and to promote patient safety.

CONCLUSION

We conclude that the identified evidence reiterates divergences about the volume, frequency, preparation solution, technique and devices used to perform flushing. New flushing technologies can reduce complications such as obstruction and infection. Our findings support the development of educational interventions to expand the nursing team's knowledge about the maintenance of intravenous catheters used in patients undergoing intravenous therapy, as well as the proposition of strategies aimed at guiding the conduct and promoting the adherence of such professionals to the practice of flushing at the different levels of care.

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