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The Midline Catheter Within the Context of Home Intravenous Antibiotic Treatment

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ABSTRACT

Home intravenous antibiotic treatment (HIAT) consists of the administration of intravenous antibiotic therapy in the home of the patient. Short peripheral intravenous catheters have long been the first option for antimicrobial therapies. However, these devices are known for their short durability. At present, the midline catheter is one of the median duration devices most commonly used and recommended within the context of HIAT. The objective of this study was to evaluate the occurrence of complications related to midline catheters implanted by a vascular access team in patients undergoing HIAT within the context of home hospitalization. This was a prospective observational study, which consecutively included 77 patients. A total of 92 midline catheters were analyzed. The complications observed were device obstruction (8.7%), infiltration (3.3%), dislodgement (2.2%), and thrombosis (1.1%). Bivariate analysis showed that the pH of the drug and ertapenem administration were associated with catheter obstruction. The authors found

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a low prevalence of midline catheter-associated complications in patients undergoing HIAT. The use of antireflux needleless connectors should be considered to reduce obstructions. In addition, algorithms that include the variable of type of daily life activity should be developed for deciding the most appropriate catheter for home hospitalized patients receiving HIAT.
Key words: clinical safety, complication, home hospitalization, home intravenous antibiotic treatment, midline catheter, obstruction, peripheral device, ultrasound, vascular infusion access team, venous access

INTRODUCTION

Home intravenous antibiotic therapy (HIAT) is a practice that is increasingly more frequently used for the intravenous administration of antibiotics to patients on a home hospitalization regimen. Multidisciplinary teams made up of medical, nursing, and administrative personnel have been formed for the administration of HIAT. This therapeutic modality has been shown to be effective and safe and also to reduce costs.[1] A recent meta-analysis showed that HIAT reduces the risk of readmission and long-term admission, as well as anxiety and depression, in patients with chronic diseases compared to conventional admissions in a hospitalization unit.[2]

Short peripheral intravenous catheters (PIVCs) have long been the first option for antimicrobial therapies, with the study on the prevalence of nosocomial infections in Spain (EPINE, 2021) reporting that 76.57% of hospitalized patients have a peripheral venous device.[3] However, the short durability (38–96 hours) and the high rate of failure of around 30% to 40% requires patients to undergo multiple venipunctures until the end of treatment.[4,5] In addition, some studies describe that venous access may be difficult and require more than 3 venipuncture attempts in 36% of hospitalized patients.[6] Likewise, patients describe the vascular access procedure as a very negative experience and consider it to be cruel.[7]

Despite the reported results in relation to the cost-effectiveness of the HIAT programs, vascular access is a conditioning that may affect treatment times and patient clinical safety. One study reported that, among the complications observed in patients with home antimicrobial therapy, 25% were due to vascular access.[8]

The 2019 guidelines of the Spanish Society of Clinical Microbiology and Infectious Diseases and the Spanish Home Hospitalization Society recommended that, for treatments longer than 7 days, the use of a median duration device should be evaluated to reduce the need for multiple venipunctures.[1] In addition, ultrasound-guided insertion was recommended to increase the success rate to more than 98%.[1,9-11] Adequate insertion can be ensured by vascular access teams (VATs), which have the necessary expertise to perform the process of vascular access. Indeed, the implantation of venous devices by VATs has shown a reduction in catheter-associated complications.[9,12]

The decision to use vascular access in HIAT programs is key for the success of these programs. Currently, one of the median duration devices most commonly used is the midline catheter. According to a recent meta-analysis, this peripherally inserted venous catheter presents a low prevalence of complications in patients admitted to conventional hospitalization units, with 4.1% of thrombosis, 3.8% of occlusion, 3.4% of phlebitis, and 1.9% of infiltration.[13] A recent multicenter study described a risk of midline catheter obstruction of 2.1%, which is lower than the 7.0% reported for peripherally inserted central catheters.[14] Likewise, this latter study reported a lower risk of catheter-associated bloodstream infections (CABSIs) of 0.4% versus 1.6%, and a similar prevalence of catheter-associated thrombosis.[14] In view of this low prevalence of complications and prolonged durability compared to other types of devices and taking into account the costs of the insertion of central line venous catheters, the midline catheter is currently considered a cost-effective device.[9,15] However, one study on HIAT reported 33% of midline catheter failures.[16] This study observed that the most prevalent adverse events were related to ultrasound-guided versus non–ultrasound-guided insertion (13.5% versus 19.5%, respectively). Another study described 30% of complications associated with the midline catheter in home-hospitalized patients compared to 22% in patients with conventional hospitalization, although these values were not statistically significant.[17]

All of the above demonstrates the controversy regarding the use of midline catheters in HIAT programs. Therefore, the objective of the present study was to evaluate the occurrence of complications related to midline catheters inserted by a VAT in patients undergoing HIAT within the context of home hospitalization.

METHODS

Study Design, Setting, and Participants

This was a prospective, observational study that consecutively included 77 patients and the insertion of 92 midline catheters from January 1, 2019, to September 1, 2022, in the Hospital del Mar de Barcelona. All patients were over 18 years of age and received intravenous antibiotic treatment within the context of a home hospitalization

program. Each patient underwent ultrasound-guided insertion of a midline catheter by the VAT, composed of nurses with expertise in vascular access (VAT hospital certificate of quality 001/2022). Some patients (n = 13) had more than 1 device due to reinitiation of antimicrobial treatment after finalization and subsequent withdrawal of the midline catheter or due to the development of a catheter-associated complication requiring the removal of the device and the insertion of another.

Inclusion-Exclusion Criteria

Patients who were candidates to receive the midline catheter had to fulfill the 4 criteria described by the Infusion Nurses Society (INS)[9]: (1) intravenous therapy for 1 to 4 weeks; (2) osmolarity <900 Osm/L; (3) medications and solutions that are well-tolerated by peripheral veins; and (4) the ultrasonographic confirmation that the vein/catheter ratio was <45%.[9] These devices were inserted by the VAT of the Hospital del Mar. Exclusion criteria included patients with a midline catheter inserted and manipulated in a conventional hospitalization unit and later transferred to home hospitalization.

Procedure

The home hospitalization team requested insertion of the intravenous device by the VAT. The type of device inserted was chosen according to the recommendations and clinical guidelines.[9] If the midline catheter was the venous device of choice, insertion was programmed in the VAT unit. The insertion of the device was ultrasound-guided in all cases, and once inserted and normal positioning was confirmed, the patient was given an *ad hoc* document describing the precautions necessary to follow with the device, as well as the identification of warning signs. The home hospitalization team was responsible for the administration of pharmacotherapy, as well as the maintenance and care of the midline catheter and its removal according to institutional protocols. In the case of suspected catheter-associated complications, the home hospitalization team consulted the VAT and the patient was evaluated by the VAT to modify treatment, if necessary, and/or for further instructions on patient management.

Variables and Data Collection

A database was specifically designed and developed for this study and was only accessible to the VAT of this institution. The data were obtained from the electronic clinical history of the patients (IMAS Informatics System). Patients were included in the study on the day of device insertion and were followed until removal of the device.

The variables collected were demographics (sex and age), disease history (Charlson index), body mass index (BMI), days of catheter placement, catheter characteristics (number of lumens, vein catheterized, device thickness, length of the device [in centimeters], venipuncture attempts), vein/catheter ratio (%), antibiotic treatment prescribed, pharmacotherapeutic characteristics (administration in bolus or continuous perfusion pump, pH-metry, and osmolarities), and reason for removal (end of treatment or suspicion of infection). The dependent variables were complications associated with the midline catheter (catheter-associated bacteremia, infiltration, device obstruction, phlebitis, dislodgement, and symptomatic thrombosis).

Data Sources/Measurement

The midline catheter was defined as a venous device inserted in a peripheral vein of the upper arm through the basilic, cephalic, or brachial vein with the end point located at the level of the axilla.[9] This study used the concept of CABSI reported by the INS,[9] including the midline catheter, since they are excluded within the concept of central-line associated bloodstream infection. CABSI was defined according to the criteria of the Centers for Disease Control and Prevention (CDC)/National Healthcare Safety Network (NHSN).[18] CABSI was considered as a primary infection if there were no other clinical signs or symptoms of another infectious foci. The catheter-associated infection was defined as follows: (1) the catheter had been inserted at least 48 hours before the onset of sepsis, and/or (2) microbiological growth (bacteria and/or fungi) of at least 15 colony forming units was present on the end of the catheter identical to a positive blood culture sample, and/or (3) there were more than 2 hours between a positive culture extracted from the catheter and a positive culture obtained peripherally.[18] All the CABSIs were validated by the infection control program of the institution.

Infiltration and leakage were defined as the exit of pharmacotherapy outside the blood vessel, with infiltration being considered when the drug was not vesicant and leakage when it was.[19] Obstruction was defined as the inability to administer solutions or to extract blood from the vascular access device.[9]

Phlebitis was defined as inflammation of the vein in which the catheter was placed and was evaluated with a visual infusion phlebitis scale.[9] Dislodgement was registered as movement of the catheter inside or outside the insertion site with the point at a suboptimal level.[9] Thrombosis was defined as obstruction of the venous vessel, including a thrombus hindering venous return at the site of the vascular access.[9]

The Charlson Comorbidity Index (CCI) was used to evaluate associated comorbidities.[19] The pH-metry and osmolarities were based on the standardization described in the literature.[20] Insertion, maintenance, and removal of the midline catheter were carried out according to institutional protocols based on the CDC/NHSN guidelines and INS 2021 *Infusion Therapy Standards of Practice* (the *Standards*).[9,21]

Ethical Considerations

The data were collected from electronic clinical records, and thus no informed consent was requested. Approval for

the study was granted by the clinical research ethical committee (Spanish acronym, CEIC) of the Parc de Salut Mar. The study was assigned number 2018/8113/I.

Statistical Analysis

The analysis unit was the catheter, while the sociodemographic and clinical variables were assessed per patient. Qualitative variables were described with absolute frequencies and percentages. The description of quantitative variables was performed using the mean and standard deviation (SD). The Kolmogorov-Smirnov test was used to assess the normality of distributions.

Patient characteristics and clinical variables were compared according to the presence of catheter obstruction. For the qualitative variables, the x^2 test (Fisher exact test correction in the event of expected frequencies <5) was used. The Student *t*-test was performed to compare quantitative variables with the Mann-Whitney *U*-test for variables with a nonnormal distribution. The variable antimicrobial was recorded for the bivariate analysis due to the low prevalence of some antimicrobials, and these were grouped into ertapenem, piperacillin/tazobactam, and others. The analyses were performed using the SPSS software version 25. For all tests, a statistically significant difference was set at a value of $P < .05$.

RESULTS

Characteristics of the Patients

A total of 92 midline catheters were inserted in 77 patients under home hospitalization with an antimicrobial pharmacotherapy schedule, with a mean of 1.1 (SD = 0.34) midline catheters per patient. The mean age of the patients was 73.3 years (SD = 14.9), 55.8% (n = 43) were women, and the mean BMI was 29.62 kg/m^2 (SD = 10.8). The most prevalent pathological history was peripheral artery disease in 31.2% (n = 24) of cases, and the mean CCI score was 5.9 points (SD = 3.1; Table 1).

TABLE 1

Characteristics of the Patients

Variable (Analysis Unit: Patients)	Total n = 77
Sex, n (%)	
Male	34 (44.2)
Female	43 (55.8)
Age	73.30 (14.9)
History, n (%)	
Coronary disease	1 (5.2)
Congestive heart failure	18 (23.4)
Peripheral artery disease	24 (31.2)
Cerebrovascular disease	7 (9.1)
Dementia	13 (16.9)
COPD	11 (14.3)
Connective tissue disease	6 (7.8)
Peptic ulcer	0
Mild liver disease	4 (5.2)
Moderate/severe liver disease	3 (3.9)
Diabetes mellitus	21 (27.3)
Diabetes mellitus with distant complications	7 (9.1)
Hemiplegia	1 (1.3)
Kidney disease	18 (23.4)
Tumor, leukemia, lymphoma	13 (16.9)
Metastatic disease	7 (9.1)
HIV	0
Charlson	5.91 (3.1)
Number of midline catheters	1.10 (0.34)
BMI	29.62 (6.78)
CRP	8.07 (3.6)

Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease; CRP, C-reactive protein; HIV, human immunodeficiency virus. The CRP was obtained considering the analysis by catheter.
The data are expressed as mean and standard deviation if not specified otherwise.

Characteristics of the Midline Catheter

Only 1 lumen was necessary for the administration of antimicrobial therapy in 98.9% of the devices inserted, with 78.3% (n = 72) being inserted in the basilic vein, and in 65.2% (n = 60) of patients, the insertion was in the upper right extremity. The vein/catheter ratio was 24.15% (n = 11.6), and the mean number of venipuncture attempts for successful insertion was 1.03 (SD = 0.39). The dwell time of the midline catheter was 11.6 days (SD = 6.1; Table 2).

Characteristics of the Antimicrobial Therapy

The antibiotics most frequently used were ertapenem at 30.4% (n = 28.0) and piperacillin/tazobactam at 26.5% (n = 24.0). Bolus administrations were performed in 50% of the cases. In relation to the pharmacotherapy characteristics, the mean pH was 6.4 (SD = 1.1), and the osmolarity was 377.53 Osm/L (SD = 39.6; Table 3).

Reasons for Removal of the Midline Catheter

Complications associated with the midline catheter occurred in 17.3% (n = 15) of cases, with obstruction being the most frequent at 8.7% (n = 8), followed by infiltration at 3.3% (n = 3), dislodgement at 2.2% (n = 2), and catheter-associated thrombosis at 1.1% (n = 1). Regarding catheter removal, 82.5% (n = 76) were removed for having completed the therapeutic schedule (Table 4).

Factors Related to Midline Catheter-Associated Obstruction

As described above, obstruction was the most frequent complication with the midline catheter, with the following

TABLE 2

Characteristics of the Midline Catheter

Variable (Analysis Unit: Catheters)	Total n = 92
Catheter, n (%)	
Midline catheter	8 (8.7)
Mini-midline catheter	84 (91.3)
Catheter length, cm	10.68 (2.5)
Vein/catheter ratio, %	24.15 (11.6)
Number of venipuncture attempts	1.03 (0.3)
Catheter duration, days	11.6 (6.1)
Number of lumens, n (%)	
1 lumen	91 (98.9)
2 lumens	1 (1.1)
Vein, n (%)	
Basilic	72 (78.3)
Brachial	13 (14.1)
Cephalic	7 (7.6)
Laterality of catheter insertion, n (%)	
Right	60 (65.2)
Left	32 (34.8)

Abbreviation: Cm, centimeters.
The data are expressed as mean and standard deviation if not specified otherwise.

TABLE 3

Characteristics of the Antibiotic Therapy

Variable (Analysis Unit: Catheter)	Total n = 92
Antibiotics, n (%)	
Amikacin	1 (1.1)
Cefazolin	1 (1.1)
Cefepime	3 (3.3)
Cefotaxime	4 (4.3)
Ceftacidime	8 (8.7)
Ceftorolan/tazobactam	1 (1.1)
Ceftriaxone	11 (12.0)
Daptomycin	1 (1.1)
Daptomycin/ertapenem	1 (1.1)
Ertapenem	28 (30.4)
Fluconazol	2 (2.2)
Ganciclovir	1 (1.1)
Meropenem	3 (3.3)
Piperacillin/tazobactam	24 (26.1)
Teicoplanin	2 (2.2)
Tobramicin	1 (1.1)
Ph	6.42 (1.1)
Osmolarity, Osm/L	377.53 (39.6)
Administration, n (%)	
Pump	46 (50)
Bolus	46 (50)

The data are expressed as mean and standard deviation if not specified otherwise.

characteristics being related to the occurrence of this complication: drug administration in bolus (P = .07), a high pH level (P = .02), and the administration of ertapenem (P = .004; Table 5).

DISCUSSION

The results of this study show a high success rate of 82.5% with the use of midline catheters within the context of home-hospitalized patients receiving HIAT. The most frequent complications observed were catheter obstruction (8.7%), followed by infiltration (3.3%), dislodgement (2.2%), and, lastly, catheter-associated thrombosis (1.1%). However, compared to the present study, previous studies have reported higher complication rates associated with this catheter in this context, suggesting that the success of the midline catheter in patients receiving HIAT is multifactorial and may be secondary to several key points.[9,16,17]

Regarding the low frequency of thrombotic complications observed in the present study, this may be related to the indication for device use. The mean pH levels and osmolarities of the pharmacotherapy prescribed were within the range of the guidelines and the reports of original studies designed to avoid damage to the vascular endothelium and the development of a thrombotic process.[9,20] In addition, ultrasonographic evaluation of the vascular bed by the VAT allowed standardized and systematized evaluations of the adequacy of the vessel for venous insertion of the device.[10] Ultrasonography also ensured that the vein catheter ratio of 45.0% was not surpassed to avoid impeding venous return, and, thus, in this study, the mean volume occupied was 24.2%.[9,10] Moreover, the ultrasound-guidance technique is recommended in the PERSEUS document,[22] as well as by the Gavecelt group, who also described an increase in the success of ultrasound-guided venipuncture to more than 98%.[11] In fact, studies on non-radiologically guided insertion of midline catheters have reported an elevated rate of catheter-related adverse events.[16] Along the same line, a systematic review and meta-analysis described the importance of not only the use of ultrasound guidance in the insertion of midline catheters but also the expertise of the insertion technique to reduce catheter-associated thrombotic events, further highlighting the need for professional teams with expertise in the insertion of these devices. It is of note that, with the use of an expert team, the mean number of venipuncture

TABLE 4

Reasons for Removal of the Inserted Midline Catheter

Variable (Analysis Unit: Catheter)	Total n = 92
Catheter-associated complications, n (%)	15 (17.3)
Kinking	1 (1.1)
Dislodgement	2 (2.2)
Infiltration	3 (3.3)
Obstruction	8 (8.7)
DVT	1 (1.1)
CABSI	0
Reasons for catheter removal: n (%)	
End of treatment	76 (82.5)
Suspicion of infection	1 (1.1)

Abbreviations: CABSI, catheter-associated bloodstream infection; DVT, deep vein thrombosis.
The data are expressed as mean and standard deviation if not specified otherwise.

attempts in the present study was 1.03.[11,12,22] The low prevalence of thrombosis of 1.1% in this study is very different compared to a study based on home hospitalization patients that reported up to 13.0% of catheter-associated thromboses,[17] which is well above the standard of 3.0% of thrombosis described in the literature.[23]

In the present study, CABSI was not detected, likely due to the quality of the management and maintenance of these devices, as well as the training and adherence to institutional protocols, which predispose to normal catheter functionality and reduce the risk of associated infectious complications.[9,21] Institutional protocols, based on the *Standards*, enable the implementation of measures supported by a higher level of evidence.[9] Additionally, having a team of home hospitalization professionals and a well-established and expert VAT contributed to and improved outcome indicators. The quality of the expert nursing teams in the management and maintenance of these devices, coupled with training and adherence to institutional protocols, predisposed to the normal functioning of the catheter and reduced the risk of associated infectious complications, as described in other studies.[9,21,24]

In a previous study, 73% of the professionals did not adhere to either the protocols or recommendations of the guidelines.[25] Likewise, some studies demonstrate the need for periodic training programs that cover and impact adherence to institutional protocols.[24] These training programs are essential to avoid unjustified clinical variability and, consequently, deficient quality of management and maintenance. Indeed, one study described the importance of identifying, detecting, and developing strategies for improving the quality of the interventions involving vascular access.[25]

TABLE 5

Bivariate Analysis of the Factors Related to Midline-Associated Obstruction

Variable (Analysis Unit: Catheter)	No Obstruction n = 84	Obstruction n = 8	*P* value
Sex, n (%)			
Male	37 (44.6)	5 (55.6)	.53
Female	47 (55.4)	3 (44.4)	
Age	73.75 (15.1)	69.22 (13.6)	.34
CHARLSON	5.85 (3.1)	5.67 (3.2)	.88
BMI	30.08 (6.49)	25.62 (8.40)	.48
CRP	8.07 (3.7)	8.13 (2.6)	.86
Season of the year, n (%)			
Summer	17 (20.5)	3 (33.3)	.76
Fall	27 (32.5)	3 (33.3)	
Winter	20 (24.1)	2 (22.2)	
Spring	19 (22.9)	1 (11.1)	
Vein catheter ratio, n (%)	24.48 (11.7)	20.88 (11.2)	.43
Catheter duration, days	11.79 (6.3)	9.89 (5.4)	.54
Vein, n (%)			
Basilic	63 (75.9)	8 (100)	.25
Brachial	13 (15.7)	0	
Cephalic	7 (8.4)	0	
Laterality of catheter insertion, n (%)			
Right	54 (65.1)	6 (66.7)	.92
Left	29 (34.9)	3 (33.3)	
pH level	6.3 (1.1)	7.26 (0.7)	.02
Osmolarity, Osm/L	377.32 (40.5)	379.4 (31.6)	.57
Administration, N (%)			
Pump	44 (53.0)	2 (22.2)	.07
Bolus	40 (47.0)	6 (77.8)	
Antibiotics, n (%)			
Others	38 (45.9)	2 (22.2)	.004
Ertapenem	21 (25.3)	6 (77.8)	
Piperacillin/ tazobactam	24 (28.9)	0	

Abbreviations: BMI, body mass index; CRP, C-reactive protein.
The data are expressed as mean and standard deviation if not specified otherwise.

Infiltration was found in 3.3% of cases, which is lower than that reported in 2 similar studies reporting values of 13.3% and 40.0%, respectively.[16,17] However, the latest meta-analysis described infiltration in 1.9% of patients

treated by conventional hospitalization.[13] These results may be associated with the type of infusion performed, ie, free-flow or with a perfusion pump. One study with a small sample size reported a higher rate of catheter failure in patients receiving pharmacotherapy by continuous perfusion pump; nonetheless, more studies are needed to confirm this relationship.[26]

In the present study, the obstruction rate was 8.7%, which is similar to the 8.2% reported in the study by Comas et al.[15] However, in other studies, the prevalence of obstruction reported was as high as 33.0%,[16,17] while a meta-analysis of hospitalized patients showed a much lower prevalence of 3.8%.[13] These elevated frequencies of obstruction may be related to the daily life activities of home-hospitalized patients, which might favor blood reflux at the distal point of the catheter, especially in the case of an antibiotic administered in bolus. One study described similar results to this study with a greater prevalence of obstructions of 28.4% when the device was intermittently permeabilized with saline solution compared to the 6.6% described with continuous perfusion of this solution.[27,28] However, in the pediatric context, a cohort study reported a similar prevalence of 6.0% of obstructions regardless of whether the administration was in bolus or by continuous perfusion for the maintenance of the vascular access device.[27] Within the context of HIAT, continuous administration of pharmaceuticals and/or the maintenance of devices by flushing with continuous perfusions of saline solution should be explored in order to reduce these high levels of obstruction, taking into account, as reported previously, that home hospitalization teams are specialized, well-established, and adhere to institutional protocols. Nevertheless, further studies are needed to demonstrate this hypothesis.

As for the variables related to catheter obstruction, the result of the bivariate analysis showed that these obstructions are related to drugs with an alkaline pH due to the intraluminal creation of drug precipitates as described in the guidelines.[9,29] This coincides with the results of the present study showing that, in 75% of the cases, the drug related to the obstructions was ertapenem, which has a pH of approximately 7.8, ie, an alkaline pH involving a greater probability of obstruction.[20] If a cause–effect of this problem of obstruction is established, it can be determined that the quality of maintenance and flushing of the vascular access devices with the push-pause technique is key for normal catheter functioning by removing hematic remains and pharmacotherapeutic precipitates adhering to the endoluminal wall.[9]

LIMITATIONS

This study has some limitations, among which is the design itself. This was a single-center study with a descriptive design that did not allow conclusive establishment of associations among variables. There was also a confounding bias in which the care and maintenance of these vascular access devices interfere with the occurrence of complications associated with the catheter. This bias was reduced because the manipulation and care of the device were carried out by a small, experienced group of professionals with expertise in antibiotic therapy and, thus, with little professional variability.

CONCLUSIONS

The authors found a low prevalence of complications associated with the use of midline catheters in the context of home-hospitalized patients receiving HIAT. However, further studies are needed to establish the viability of midline catheters to consolidate improvements related to the clinical safety of patients requiring vascular access. Despite the low prevalence of midline catheter-associated complications, it is important to establish the most effective method for flushing vascular access devices in this setting with the design of prospective studies. The use of antireflux needleless connectors that inhibit blood reflux by the catheter when the device is not in use should be considered. It is also important to have a protocol of catheter clearance, which might solve this problem. Lastly, it would be interesting to create algorithms for deciding the most adequate catheter for home hospitalization patients, including the type of daily life activity of the patient. Hospital institutions should continue to create specialized teams in different areas, such as the process of vascular access, to reduce the unjustified clinical variability, and strategies of improvement should be implemented to increase the quality of care.

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