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Midline catheters – what could be done better? A retrospective evaluation of clinical registry

Cewniki pośrednie – co można zrobić lepiej? Retrospektywna analiza kart obserwacji

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STRESZCZENIE

CEWNIKI POŚREDNIE – CO MOŻNA ZROBIĆ LEPIEJ? RETROSPEKTYWNA ANALIZA KART OBSERWACJI

Wstęp. Cewniki pośrednie (ang. midline catheters – MCs) to kolejna opcja wyboru dostępu naczyniowego obok powszechnie stosowanych krótkich kaniul obwodowych i kaniul centralnych wprowadzanych centralnie oraz obwodowo.

Cel pracy. Celem badania była analiza implementowanego w czasie pandemii COVID-19 rozwiązania w ośrodku, w którym dotychczas nie stosowano dostępu pośredniego.

Materiał i metody. Analizie retrospektywnej poddano karty obserwacji 98 cewników pośrednich założonych u pacjentów dorosłych.

Wyniki. Średni czas od przyjęcia do założenia cewnika wyniósł 15 dni. Wskazaniami był trudny dostęp dożylny (83%) oraz przewidywana terapia dożylna >6 dni (17%). Średni czas przeżywalności kaniuli wynosił 9 dni. Najczęstszymi przyczynami usunięcia kaniuli było zakończenie terapii dożylnej (44%) i niedrożność cewnika (36%).

Wnioski. Uzyskano wysoki poziom przedwcześnie usuniętych cewników. Wysoki odsetek cewników pośrednich usuniętych przed końcem terapii dożylnej może świadczyć o niskiej jakości opieki nad dostępami naczyniowymi i potrzebie nieustannej edukacji personelu medycznego. Uzyskane wyniki należy potwierdzić w prospektywnym badaniu zaplanowanym na ich podstawie w celu określenia koniecznych interwencji dla poprawy jakości opieki nad dostępami naczyniowymi.

Słowa kluczowe: **pielęgniarki, kaniulacja, utrudniony dostęp dożylny, zespół dostępu dożylnego, cewniki pośrednie**

ABSTRACT

MIDLINE CATHETERS – WHAT COULD BE DONE BETTER? A RETROSPECTIVE EVALUATION OF CLINICAL REGISTRY

Introduction. Midline catheters (MCs) are an option for vascular access alongside the commonly used short peripheral intravenous catheters, centrally and peripherally inserted central catheters.

Aim. The aim of this study was to evaluate the solution implemented during the COVID-19 pandemic in a centre where MC access had not been used before.

Material and method. It was an observational retrospective evaluation of the 98 medical registries of adult patients.

Results. The mean time from hospital admission to midline catheter insertion was 15 days. The most common indications for the catheter implementation were: difficult intravenous access (83%) and expected time hospital stay >6 days (17%). The mean dwell time of the catheters was 9 days. The most common reasons for removal were: the end of intravenous therapy (44%) and catheter blockages (36%).

Conclusions. A high level of prematurely removed catheters was observed, despite the existence of a hospital protocol. The high percentage of MCs removed before the end of intravenous therapy may be indicative of the poor quality of care and the need for continuous education of medical staff. The results obtained should be confirmed in a prospective study planned on their basis in order to identify interventions which are necessary to improve the quality of vascular access care.

Key words: **nurses, cannulation, difficult intravenous access, intravenous access team, midline catheters**

INTRODUCTION

Midline catheters (MCs) are an option for vascular access alongside the commonly used short peripheral intravenous catheters (PIVs), central cannulas (centrally inserted central catheters - CICCs), and peripherally inserted central catheters (PICCs). They are used in patients with difficult intravenous (IV) access [1-3] and those whose planned therapy is expected to exceed six days. In such situations central venous catheters can be used, but these carry a risk for more serious complications (e.g. central artery puncture, pneumothorax, hematoma, central venous thrombosis). Midlines, with available lengths from 4 to 25 cm and diameters from 2 to 6 Fr, are inserted under ultrasound guidance into peripheral veins, usually the deep veins of the arm, using the Seldinger technique (Fig. 1). The introduction of midlines into clinical practice has made it possible to reduce the number of cannulations which must be performed by a doctor, as the peripheral character of MCs enables to insert them by competent nursing staff.

The inclusion of nurses in teams enrolling patients for the procedure and obtaining appropriate vascular access, also under ultrasound guidance, makes it possible to reduce the number of unsuccessful PIVs attempts and to lower the number of central venous cannulations [5,6]. This solution is used in many countries [7]. To the best of our knowledge, no Polish studies presenting experience in this area have been published. The aim of this study was to analyse the solution implemented during the COVID-19 pandemic in a centre where MC access had not been used before.

MATERIALS AND METHODS

The study was reported to the Bioethics Committee of the Medical University of Warsaw (AKBE/96/2022). It was an observational retrospective evaluation of the medical registries of adult patients who had MCs inserted during their hospitalisation at the University Clinical Centre of the Medical University of Warsaw from January to October 2021.

Enrolment of patients

Patients, who were to have midline catheters inserted, were pre-screened for enrolment by the staff of their ward when: there were no options of superficial venous cannulation left and/or their intravenous therapy with solutions not requiring a CVC was expected to exceed 6 days. Subsequently a trained member of the nursing team followed the enrollment protocol and performed the cannulation. Besides having experience in ultrasound-guided needle insertion, each of the members of the specialized nursing team had to take compulsory seven-hour certified theoretical and practical training in ultrasound-guided peripheral vein cannulation and the Seldinger technique at the Centre for Medical Simulation and Innovation of the Medical University of Warsaw. The first five insertions were supervised by a doctor or nurse with experience in this area.

Procedure for placing catheters

After obtaining the patient's informed consent in line with the required hospital procedure, an ultrasound examination was performed using the Vygon Sonoscanner

Fig 1. Midline catheter placed on patient's arm

Fig 2. Midline catheter implantation kit

QScan instrument with a 12.5 MHz 4.0 cm linear probe. During the examination, the following were assessed: the presence of pressure-prone deep veins of the arm with a diameter > 3 mm and the possibility to visualise the vein and the appropriate distance from the planned insertion site to the end of the length of a particular catheter.

The insertion procedure was performed using the Smartmidline Vygon kit according to the principles typical of ultrasound-guided central vessel cannulation, in most cases adopting the short axis approach. After cannulation, the catheter port was secured in the typical manner with an Octopus extension set or a Vadside or Bionector needle free connector. The catheter was secured with a sutureless Grip-lock system and with a 10 x 12 cm transparent dressing. A sticker identifying the type of access was placed on the extension drain (Fig. 2).

Data collection

After obtaining venous access, the operator filled out an MC register and an observation sheet. The patient's ward team received additional verbal instructions and an educational booklet on vascular access care with an emphasis placed on venous access focusing on the maintenance of indwelling catheters, even though there is a hospital procedure providing instructions on how to use them.

Daily observation of the catheter, including assessment of the dressing and the surrounding skin, patency, and potential for blood aspiration was routinely carried out by the access team at the patient's bedside. An entry was made in the register and observation sheet if a decision was made to remove the catheter.

To collect data for the study, the following variables were assessed: patient gender and age, indication for insertion, time elapsed from hospital admission to the insertion, length of catheter used, its diameter, catheter dwell-time and reason for its removal.

Statistical analysis

In order to select the appropriate statistical tests for analysing the relationships between variables, it was verified whether the assumptions allowing the use of each test were fulfilled, i.e.: the type of variables, the normality of distribution and appropriate sample size were checked. In the case of quantitative variables, the presence of outlier observations was examined, and if identified, they were subjected to winsorisation. The following statistical tests and methods were used: the Mann-Whitney U test, the Kruskal-Wallis test, Spearman's linear correlation and Pearson's Chi-Square test. The results obtained were considered statistically significant if $p<0.05$. The IBM SPSS Statistics 27 pack was used to perform the calculations.

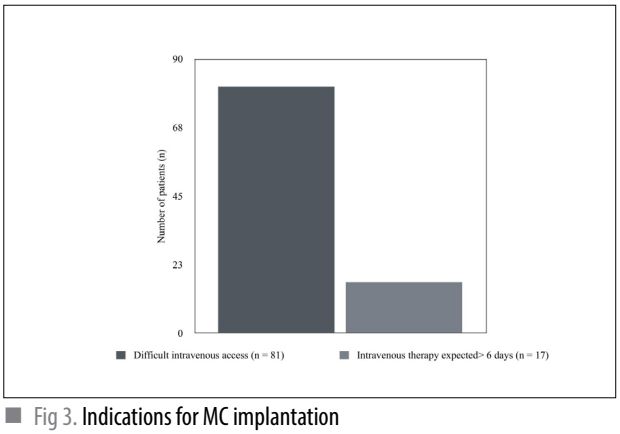

Fig 3. Indications for MC implantation

RESULTS

Analysis was conducted of the observation charts of 98 patients with indwelling catheters inserted over a 10-month period in different hospital wards. Out of this number, 53 patients were women (54%) and 45 men (46%). The mean age was 64 years (range: 20-96 years). Intravenous access was achieved with a success rate of 92%. Most of the catheters inserted were between 12 and 20 cm long, with diameters of 3 and 4 Fr (Tab. 1).

Tab. 1. Length and diameter of MC inserted

Length	10 cm	12 cm	15 cm	20 cm	25 cm
Number of catheters (n)	7	29	26	30	6
Diameter	**2 Fr**	**3 Fr**	**4 Fr**	-	-
Number of catheters (n)	26	36	36	-	-

The mean time from admission to catheter insertion was 15 days. The earliest that patients were enrolled for cannula insertion was on the day of admission, while the longest time from admission to insertion was 93 days. Seven patients had catheters inserted more than once. The main indication was difficult intravenous access (83%). When two indications occurred at the same time, the reason for requesting cannulation was entered in the documentation (Fig. 1).

Correlation analysis showed that the waiting time for a catheter insertion was dependent neither on the patient's age ($r=0.13$, $p=0.20$), gender ($U=1054.50$, $Z=-0.31$, $p=0.75$), nor on the aforementioned indications for insertion ($U=508.00$, $Z=-1.17$, $p=0.24$).

The mean catheter dwell-time was 9 days. Correlation analysis of the average dwell-time of an MC and the indication for insertion showed that in those cases where the indication was long treatment, (mean=10 days, SD 5.37) dwell-time was longer than if it was difficult access (mean=7 days, SD 4.56) and this difference was found to be significant ($U=400.00$, $Z=-2.21$, $p=0.03$).

The most common reasons for catheter removal were termination of intravenous therapy and catheter obstruction (Tab. 2). The incidence of catheter obstruction

Tab. 2. Reasons for MC removal

Reason for removal	Number of catheters (n)
End of intravenous therapy	43
Occlusion	**36**
Patient's self-removal	8
Suspected infection	5
Catheter not used	2
Recommended use time exceeded	1

by length is shown in Table 3, while the incidence of obstruction by catheter diameter is presented in Tab. 4.

Correlation analysis of the reasons for removing the insertion with other variables showed that there was no statistically significant relationship between the reasons for removal of the catheter and the indication for cannula insertion (x2 (5)=4.02, p=0.55). The correlation analysis of all reasons for cannula removal and cannula length and diameter proved unverifiable by not meeting the assumptions of the Pearson Chi-square test (due to the small study group and multiple categories in the variables more than 80% of the study groups had a value below 5).

Tab. 3. Occlusion occurrence in MC of certain lengths

Length (cm)	Number of catheters (n)	Blocked catheters (n)	Blocked catheters (%)
10	7	1	20
12	**29**	**10**	**33**
15	26	15	57
20	30	8	27
25	6	2	33

Tab. 4. Occlusion occurrence in MC of certain diameters

Diameter (Fr)	Number of catheters (n)	Blocked catheters (n)	Blocked catheters (%)
2	26	11	43
3	**36**	**14**	**39**
4	36	11	30

DISCUSSION

In the study conducted, in most cases the main reason for inserting midline catheters was difficult intravenous access. Chopra, Kaatz, Swaminathan et al. [8] in a study of 1161 catheters report such an indication in 61% of the cases examined. In such situations, obtaining vascular access using ultrasound is recommended by the Infusion Nurses Society, as it increases the likelihood of success during the first attempt [9-11]. This is supported by the experience of our team, which achieved 92% successful access and reports by other authors whose success rates were between 86 and 100% [2,7,12-17]. Training nursing staff in ultrasound-guided cannulation reduces the number of more invasive procedures, such as CVCs or also midline catheters, in cases where patients have difficult access but require short intravenous therapy. In such situations, a PIV inserted under ultrasound guidance can be used [5,15]. The use of ultrasound for cannulation by nurses increases the quality of care and patient satisfaction, allowing staff to make full use of their competencies [18]. This is confirmed by our study, as most of the procedures were performed by the nursing team, which is still not a common practice in Poland, unlike reports by foreign authors [5,19,20]. In the light of the current legal regulations in our country and the competences held by nurses, the identification of vessels under ultrasound guidance and inserting midline catheters are within the qualifications of the nursing teams [4]. Education in this area not only allows nurses to insert MCs, but also reduces the number of unsuccessful attempts at PIV insertion, thus sparing peripheral vessels, decreasing the overuse of central catheters, and reducing physician involvement in avoidable invasive procedures [21].

The mean age of the patients in our study was 64 years, which was similar to the data reported in the literature [22-24]. The advanced age of patients requiring cannulation is due to multimorbidity increasing with age and prolonged hospitalization. This may require multiple cannulations, with resulting challenges in obtaining subsequent access [25].

Analysis of the data showed that an average of 15 days elapsed from the time the patient was admitted to hospital until the insertion of the catheter, whereas in a prospective study that examined 430 patients with indwelling midline catheters, the average waiting time was 10 days [20]. This difference appears to have been due to the use of short peripheral catheters during the earlier days of hospitalisation and such a choice was due to the clinical need during the COVID-19 pandemic. Moreover, it cannot be ruled out that knowledge about the possibility to use midlines was not widespread among the hospital's staff (despite the existence of a hospital protocol) and due to the restrictions, at this time additional educational meetings could not be optimally organized. We showed that only 17% of the cases studied were ones in which the reason for cannulation enrolment was the anticipated prolonged need for intravenous access. In this group, the decision to insert a catheter had been made earlier. This was likely to be due to the commitment of the hospital's staff who had attended additional training and applied a strategy to select the optimal vascular access. Such an attitude indicates a further need for education. The analysis showed that those insertions, which were performed due to anticipated prolonged intravenous therapy, had a longer dwell-time than those due to difficult access. This difference was found to be statistically significant. It seems that the conclusions should be approached with caution, as an important limitation of the study was the way in which the patients were enrolled for cannulation, i.e. it was the reporting ward team rather than the vascular team who determined the type of indication for catheter placement.

In our study, the average catheter dwell-time was nine days. In the publications available, authors describe similar results (5 to 9 days) [1,12,13,26].

Catheter removal due to the termination of intravenous therapy related to 44% of the catheters. A limitation of the study was the inclusion of patients discharged from hospital and deceased ones, which does not make it possible to draw conclusions about the success of implementing a strategy to select an appropriate vascular catheter.

It must be noted that in the results presented, complications in the form of catheter obstruction occurred in 36% of the cases, which is more than the data reported in the literature, according to which, this problem affects between 2 and 27% of cases [7-8,10,12,21]. It seems that some reasons for this difference could have been: the overall poor quality of vascular access care, staff shortages, work overload during the pandemic, or insufficient centre

experience. To address this issue, following the analysis a further programme of staff education in vascular catheter care has been implemented, including the development of a management procedure algorithm. In addition, this is an area that needs to be examined prospectively. Appropriate interventions should be implemented in the future, taking into account the quality of care, staffing standards and their level of training in using this kind of vascular access.

The study registry did not include a breakdown of mechanical complications into subgroups. For example, cases of venous thrombosis associated with the presence of a catheter were not recorded, although these are examined in detail in progressive publications by other authors, as it is routine to assess for thrombosis based on clinical symptoms (e.g. using the VIP scale). Thus, a retrospective analysis does not provide an opportunity to address these data. These factors should be the subject of further research in this area.

Suspected infection in the analysed registry affected 5% of midline catheters, a high rate compared to other works, which reported that this reason for removal occurred in between 0 and 0.3% cases [8,12]. Similarly to catheter obstruction, this may be related to the poor quality of care for vascular accesses, as the epidemiological principles of care for midline catheters are the same as for other types of vascular access. However, this result should be approached with caution, since this complication was recorded on the basis of the clinical assessment of the teams on the patients' wards. Confirmation in the form of a microbiological test result of the catheter itself was not received and these decisions were up to the team managing the patient in question.

In the authors' clinical practice to date, the only alternative access to peripheral cannulas have been centrally inserted central catheters. Midlines fill the niche between short cannulas and central catheters and, in many situations, may be the optimal solution to address the current needs of the patient. However, the introduction of such a solution in centres must include concurrent theoretical and practical training (e.g. daily short training of staff on duty). As the results presented in this study have shown, without these elements, it is difficult to exploit the full potential of midlines. This topic should be the subject of further research, the results of which could form the basis for curricular changes in training medical staff in vascular access and the development of a system for monitoring the quality of nursing care in this area.

Despite the small number of patients, the registry presented is, to the best of the authors' knowledge, the first analysis of inserting midline catheters in Poland. It could be a starting point for further research and exchange of experience.

CONCLUSIONS

1. The care of midline catheters is not significantly different from the management of other types of vascular access, however, despite the existence of a hospital protocol, a high level of prematurely removed catheters was observed.
2. The high percentage of midline catheters removed before the end of intravenous therapy may be indicative of the poor quality of care for vascular access and the need for continuous education of medical staff.
3. The results obtained should be confirmed in a prospective study planned on their basis in order to identify interventions which are necessary to improve the quality of vascular access care.

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