COMPARISON OF UTILIZATION AND COMPLICATIONS OF PERIPHERALLY INSERTED CENTRAL CATHETERS VERSUS PERIPHERAL MIDLINE CATHETERS IN A LARGE ACADEMIC MEDICAL CENTER

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Tianyuan Xu

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This thesis was presented

by

Tianyuan Xu

It was defended on

April 28, 2016

and approved by

Thesis Chair: Lawrence Kingsley, DrPH
Professor, Infectious Diseases and Microbiology
Graduate School of Public Health, University of Pittsburgh

Committee Member: Mohamed Yassin, MD, PhD
Clinical Assistant Professor of Medicine
Medical Director of Infection Control UPMC Mercy
University of Pittsburgh

Committee Member: Jong H. Jeong, PhD
Professor and Vice Chair
Department of Biostatistics, Graduate School of Public Health
Department of Clinical and Translational Science
University of Pittsburgh

Lawrence Kingsley, DrPH

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Tianyuan Xu, MPH

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ABSTRACT

Background: Peripherally inserted central catheters (PICCs) are a commonly used central intravenous (IV) access device, which sometimes cause severe complications. Midline catheters (MC) are peripheral IV access devices that may reduce the need for central lines, and hence central line associated blood stream infection (CLABSI). The objective of this study is to compare the utilization and safety of PICC and MC.

Methods: This was a retrospective quality improvement study. Data were collected using electronic medical records and IV team insertion data. SAS v9.3 was used for analysis. Means and standard deviations were calculated to describe central tendencies and variation. Fisher's Exact Tests were used to describe strength of associations between variables.

Results: From January to May 2015, a total of 206 PICCs and 200 MCs were inserted in 367 individual patients. There was a total of 12 individual PICCs and 39 individual MCs involved with complications. MCs are associated with higher rate of non-serious complications as compared to PICCs. However, the severe complications were not significantly different between PICCs and MCs (4.9% vs. 9.0%, P=0.1182). Among the 206 PICCs, four readmissions were related to PICC issues, while among the 200 MCs, no readmission was caused by MC issues.

Conclusions: The reduction of CLABSIs could be a reasonable trade off for the increased non-severe complications associated with MCs. As technology of these devices is evolving, longer-term data will be essential to assure safety of MCs. Additional prospective studies could more objectively assess the safety and efficacy of these two devices.

Public Health Importance: A CLABSI is one of the most costly health care-associated infections (HAIs), and can cause prolonged hospital stays, increased costs and risk of mortality.

Keywords: CLABSI, PICC, midline catheter (MC), and safety

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1.0 BACKGROUND

A central line-associated bloodstream infection (CLABSI) is a serious infection which can cause prolonged hospital stays, increased costs and risk of mortality.[1] According to the Centers for Disease Control and Prevention (CDC), "a CLABSI is a primary blood stream infection (BSI) in a patient that had a central line within the 48-hour period before the development of the BSI and is not bloodstream related to an infection at another site".[2, 3] It is estimated that in the United States 30,100 CLABSIs occur in intensive care units (ICUs) and wards of acute care facilities each year.[1] According to a meta-analysis, CLABSIs were the most costly health care-associated infections (HAIs) estimated at $45,814 (95% CI, $30,919-$65,245) on a per-case basis.[4]

Between 2008-2013, CLABSIs decreased by 46% in the U.S. hospitals.[1] Comparing 2009 to 2001, there was a 58% reduction of CLABSIs in American ICUs, which were estimated to be 25,000 fewer cases.[5] Various factors contributed to the decreased infections, including performing hand hygiene and aseptic techniques, using antimicrobial/antiseptic impregnated catheters and cuffs, improving education and training, and placing by IV team.[2, 5-8] Increasing adherence to recommended best-practices for the central line insertions has also proved to be a good approach to CLABSI reduction.[5]

A peripherally inserted central catheter (PICC) is one of the most commonly used non-tunnelled central IV access devices, which has the advantage of ease of placement, safety, and cost-effectiveness compared with traditional central venous catheters (CVCs).[9, 10] However,

PICCs are also involved with two major severe complications, including CLABSI and deep venous thrombosis (DVT).[9, 11] Central line complications are a major cause for increased costs and longer hospital stay.[9, 11] A midline catheter (MC) is a peripheral IV access modality which may reduce the need for central access (CVCs and PICCs), and as a result, the CLABSIs.[12, 13]

PICCs are inserted via peripheral veins in the antecubital fossa and terminated in the superior vena cava leading into the right atrium.[14, 15] A MC has the same insertion area as a PICC, but instead of entering a central vein near the heart it ends in a large peripheral vein.[14, 15] In general, PICCs can be used for long-term intravenous (IV) access for antibiotics, chemotherapy and total parenteral nutrition (TPN) while MCs are usually used for shorter duration and some limitations with the certain medications such as amiodarone.[12, 14] According to *the Michigan Appropriateness Guide for Intravenous Catheters (MAGIC)*, when the line duration was likely to be 14 or fewer days, MCs were preferred over PICCs.[16] For cancer patients, no matter how long the line duration was, PICCs were appropriate for irritant or vesicant infusion.[16] Prolonged hospitalization and treatment for PICC-associated infections also cause additional costs.[12]

The objective of this study is to compare the safety and utilization of PICC and MC inserted at a large academic university-affiliated medical center.

2.0 METHODS

This was a retrospective study conducted at a large university affiliated medical center (>500 beds) in the state of Pennsylvania, USA. PICCs and MCs were inserted by registered nurses of the IV team following CDC's guidelines. PICCs and MCs were both manufactured by Bard (605 N. 5600 W., Salt Lake City, UT 84116, US). From January to May 2015, a total of 206 PICCs and 200 MCs were inserted in 367 inpatients in both ICUs and wards. Data including demographics, comorbidity score, length of stay (LOS), insertion location, line duration, and complications were collected using electronic medical records and IV team insertion data.

2.1 MEASURE OF ADVERSE OUTCOMES

Complications were defined as any of the following: discontinuation due to infiltration or phlebitis or catheter-related bloodstream infection (CR-BSI), deep venous thrombosis (DVT); readmission due to PICC or MC related issues; positive blood culture; and discontinuation due to non-patent, dislodgement, catheter fracture, leaking, pain or edema. Severe complications were defined as discontinuation due to infiltration, phlebitis or infection; DVT; readmission due to PICC or MC issue; and positive blood culture. We used the CDC's diagnostic definition of CR-BSI to identify infections specifically caused by PICCs and midline catheters in this study.[2]

DVTs and other complications were included when they were documented in the electronic medical records.

2.2 OTHER VARIABLES MEASURED

Demographics such as age and gender, Charlson comorbidity index (Charlson CI), length of hospital stay, insertion location, line duration, reason for insertion, and type of line were also documented in medical records. The Charlson comorbidity index was calculated by evaluating 17 disease categories such as COPD, cerebrovascular disease, diabetes mellitus, solid tumor and AIDS to evaluate patient conditions.[14] A high score means a severe condition. We compared the complications of patients with a high Charlson score and that of patients with a lower Charlson score in this study.

2.3 DATA COLLECTION AND STATISTICAL ANALYSIS

Demographics, line insertion and removal information, and complications were collected from PowerChart medical record. ICD-9 code and length of hospitalization were collected through McKesson and Theradoc medical records.

The statistical package SAS v9.3 was used for analysis with a two-sided significance level of 0.05. Mean and standard deviation were calculated to describe the central tendency and variation of variables. Fisher's Exact Tests were used to describe strength of associations between the variables measured.

2.4 ETHICS

This was a Quality Improvement (QI) study approved by the Quality Improvement of the University of Pittsburgh Medical Center April, 2015.

3.0 RESULTS

During the study period, there was a total of 206 PICCs and 200 MCs inserted in 367 inpatients. 185 patients only had PICCs and 172 patients only had MCs in one admission. 10 patients had both PICCs and MCs in one admission.

Table 1. Descriptive Patient Information

Variable	PICC (185) N (%)	Midline (172) N (%)	Sig.
Gender			0.002*
Male	114 (61.6)	78 (45.4)	
Female	71 (38.4)	94 (54.7)	
Deceased			0.145*
Yes	9 (4.9)	16 (9.3)	
No	176 (95.1)	156 (90.7)	
ICU Stay			0.113*
Yes	83 (44.9)	92 (53.5)	
No	102 (55.1)	80 (46.5)	
LOS[a]			0.350**
Number	185	172	
Mean	13.2	14.8	
Median	9.0	10.0	
Lower Quartile	6.0	6.0	
Upper Quartile	18.0	19.0	
Charlson CI			0.330**
Number	185	172	
Mean	4.8	4.5	
Median	5.0	4.0	
Lower Quartile	3.0	3.0	
Upper Quartile	6.0	6.0	

Table 1 Continued			
Age			0.037**
Number	185	172	
Mean	59.4	62.7	
Median	60.0	62.5	
Lower Quartile	49.0	53.0	
Upper Quartile	68.0	75.0	
TotICULOS[b]			0.040**
Number	83	92	
Mean	10.2	7.5	
Median	7.0	4.0	
Lower Quartile	3.0	2.0	
Upper Quartile	14.0	8.0	

* Based on Fisher's Exact Test

** Based on Kruskal-Wallis Test

[a] LOS=Length of Stay

[b] TotICULOS=Total Length of Stay in ICU

The number may not add up to 100% because of the exclusion of ten patients with both PICCs and MCs.

The age range of the 367 patients was 19–98 years old with a mean of 61 years old. The MC group was significantly older than the PICC group (p=0.037). Table 1 summarizes the descriptive information. There was no significant difference of the Charlson CI between PICC group and MC group with a p-value of 0.330. In addition, the length of stay (LOS) of the PICC group was not significantly different with that of the MC group (p=0.350). However, the total ICU length of stay of the PICC group was longer than that of the MC group (p=0.040). The distributions for gender of these two groups were significantly different with a p-value of 0.002. There was no significant difference in the death rates between the PICC group and the MC group (p=0.145). The two group patients also have the same possibility to stay in an ICU (p=0.113).

A total of ten positive blood cultures were observed, with five occurring in both PICCs and MCs (2.4% vs. 2.5%). PICCs had three Staphylococcus coagulase negative, one Micrococcus spp., and one Candida glabrata; while MCs had one Enterococcus faecium, two Escherichia coli, one Bacteroides spp, and one Candida albicans.

Table 2. Complications based on individual lines

Complications	**PICC**	**Midline**	**Sig.[a]**
	N (%)	**N (%)**	
Severe Complications			0.118
Phlebitis/infection[**]	3 (2.9)	5 (2.5)	
DVT[*]	2 (1.0)	2 (1.0)	
Readmission due to line issues[*]	4 (1.9)	0 (0.0)	
Positive culture[*]	5 (2.4)	5 (2.5)	
Infiltration[**]	0 (0.0)	9 (4.6)	
Subtotal[*]	10 (4.9)	18 (9.0)	
Minor Complications			<0.001
Pain[**]	0 (0.0)	3 (1.5)	
Non-patent[**]	3 (2.9)	17 (8.6)	
Leaking[**]	0 (0.0)	2 (1.0)	
Edema[**]	0 (0.0)	1 (0.5)	
Subtotal[*]	3 (1.5)	23 (11.5)	
Total Complications[*]	12 (5.8)	39 (19.5)	<0.0001

[*] 206 PICCs and 200 MCs.

[**] 102 PICCs and 197 MCs. 107 (26%) of the data are missing, which would be patients where the line was still in place at discharge.

The subtotals may not add up to the total number because of lines with more than one complication.

[a] Based on Fisher's Exact Test

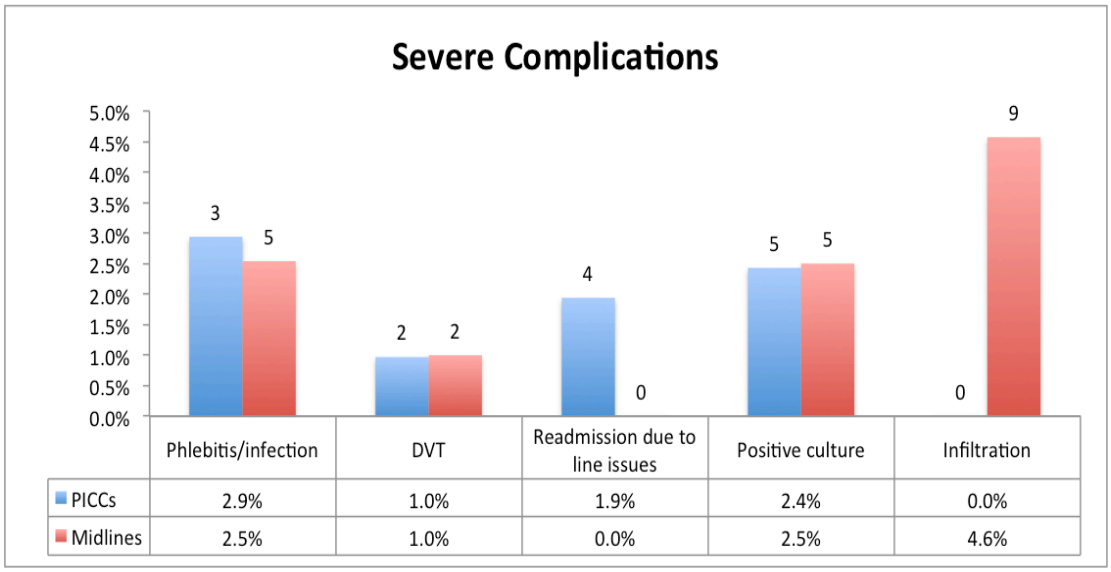

Figure 1 Severe Complications

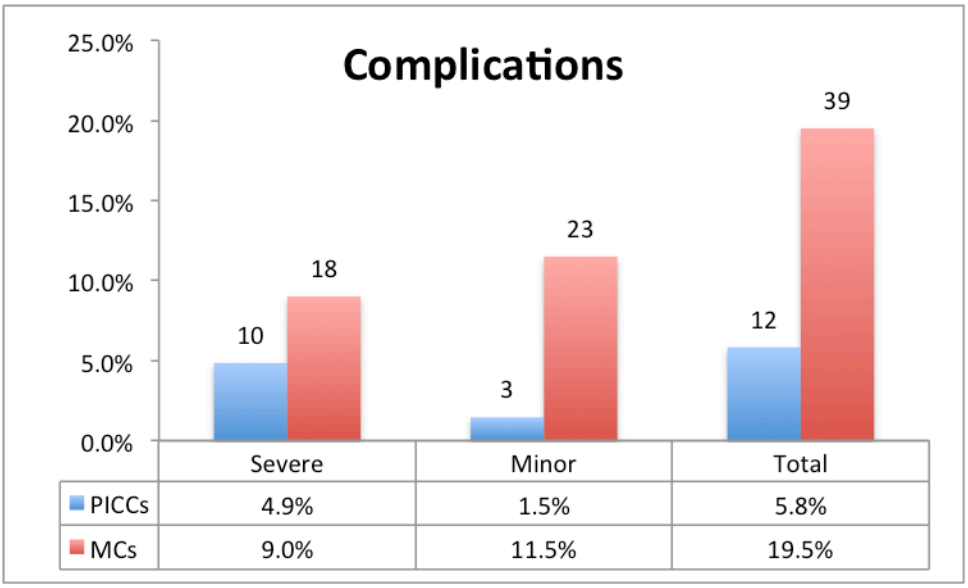

Figure 2 Total Complications

The average PICC duration of the 206 PICCs was 20 days, with a range of 1-97 days, and the average MC duration of the 200 MCs was 7 days, with a range of 0-28 days (one line was inserted and taken out on the same day). There was a total of 12 individual PICCs and 39 individual MCs involved with complications. Table 2, Figure 1 and Figure 2 shows the

complications experienced by PICC and MC patients. MCs (19.5%) were more likely to cause a complication compared with PICCs (5.8%), with a p-value less than 0.0001. However, the severe complications were not significantly different between PICCs (4.9%) and MCs (9.0%), with a p-value of 0.118. Among the 206 PICCs, four readmissions were related to PICC issues, while among the 200 MCs, no readmission was caused by MC issues.

Table 3. Complications matched by individual patient, admission, and line

PICCs	**Number of patients**	**Number of admissions/patient**	**Number of lines/admission**	**Number of complications/line**	**Total complications**
	5	1	1	1	1*5=5
	1	1	2	1+2=3	1*3=3
	3	1	1	2	2*3=6
	1	2	1	1+2=3	1*3=3
Total	10	--	12	--	17
MCs	**Number of patients**	**Number of admissions/patient**	**Number of lines/admission**	**Number of complications/line**	**Total complications**
	30	1	1	1	1*30=30
	5	1	1	2	2*5=10
	2	1	2	1+1=2	2*2=4
Total	37	--	39	--	44

Table 3 showed the complications matched by individual patient, individual admission and individual line. A total of 17 complications occurred in 12 individual PICCs inserted in ten patients. Five of the 12 PICCs were each involved with two complications. One patient experienced three different complications in two admissions, with one PICC for each admission. Another patient with two individual PICCs in one admission also experienced three complications. A total of 44 complications occurred in 39 individual MCs inserted in 37 patients. Five of the 39 MCs were each involved with two complications. Two patients each had two individual MCs in one admission, and they both had one complication for one MC.

Table 4. Complications matched by ICU Placement & Comorbidity Index

		PICC	MC	Sig[a]
Total complications	Placed ICU	6	22	0.696
	Not Placed ICU	6	17	
Severe Complications	Placed ICU	4	12	0.243
	Not Placed ICU	6	6	
Total complications	Charlson CI>=5	4	14	1.000
	Charlson CI<=5	8	25	
Severe Complications	Charlson CI>=5	4	8	1.000
	Charlson CI<=5	6	10	

[a] Based on Fisher's Exact Test

We also examined complications matched by Charlson CI and ICUs placement to see the difference in complications between the PICC group and MC group (Table 4). The results were not any different than before. Among these 406 lines, 26% (107) of the discontinuation data was missing because these patients were discharged with the line and we did not have access to the follow-up information. Therefore, the complication rate might be underestimated.

Table 5. Reasons for Insertion

	PICC (206)	Midline (200)	Sig.[a]
	N (%)	N (%)	
Reasons			<0.0001
Additional Line Needed	2 (1.0)	6 (3.0)	
Long-term ABX/Meds	131 (63.6)	0 (0.0)	
Poor IV Access	73 (35.4)	194 (97.0)	

[a] Based on Fisher's Exact Test

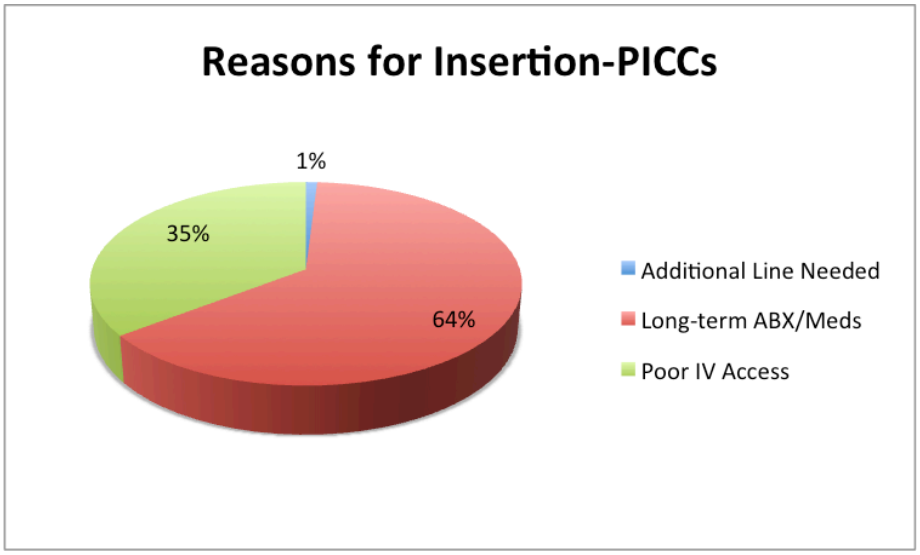

Figure 3 Reasons for insertion-PICCs

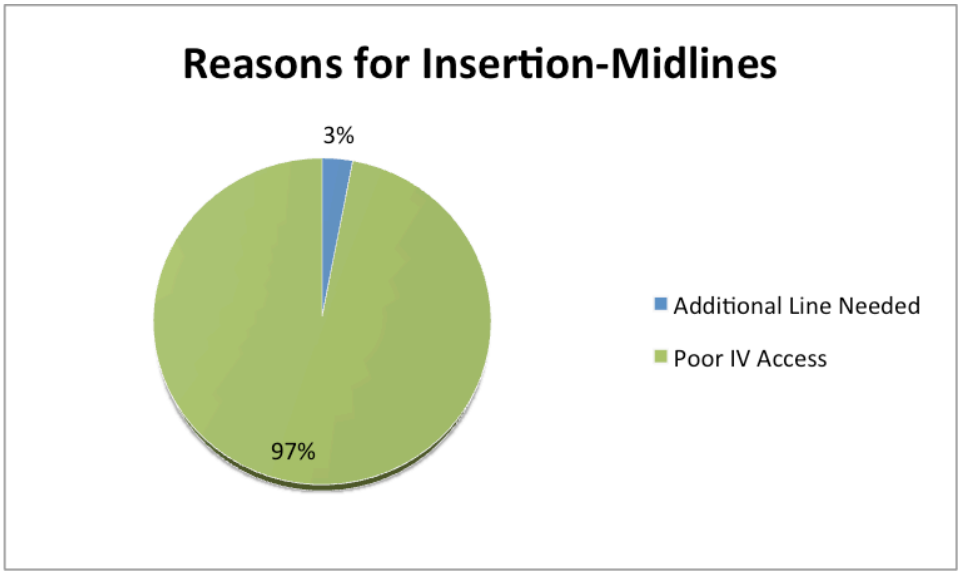

Figure 4 Reasons for insertion-MC

Table 5 and the pie charts (Figure 3-4) show that the reasons for insertion were significantly different between patients with PICCs and MCs (p=<0.0001). 63.6% of PICCs were inserted for long-term antibiotic or medication use, while no midline catheter was inserted for

this reason. 97% of midlines were inserted for poor IV access; however, this reason only accounted for 35.4% of PICC insertions.

4.0 DISCUSSION

This study shows that patients with PICCs had a significantly lower complication rate compared with MCs. However, although patients with PICCs also had a lower severe complication rate, the difference is not significant. This result is not the same as our expectation that MCs might be a safer alternative device than PICCs. However, it must be noted that the study period (five months) and sample size (406 lines) are limited; also the PICC group (61.6% male vs. 38.4% female) and the MC group (45.4% male vs. 54.7% female) had different gender distribution (p=0.002); in addition, the MC group was older than the PICC group (p=0.037). These reasons may account for the better performance of PICCs and need further research to confirm.

Most previous studies only focused on one of these two catheters and seldom compared the safety and utilization of PICCs and MCs. However, one study conducted at a large urban teaching hospital in Adelaide, South Australia included a total of 64 adult cystic fibrosis patients with 231 MCs and 97 PICCs.[14] It found similar adverse event rates among patients with PICCs and MCs, 11 and 14 adverse events per 1000 catheter days, respectively.[14] The infection rate for MCs in our study was relatively higher than that in other studies. In the cystic fibrosis study, no infections associated with MCs or PICCs were found.[14] Another descriptive study found a 2% phlebitis rate among 345 patients with MC, which is similar to the 2.5% phlebitis/infection rate in our study.[17] In our study, the positive blood culture rates of PICCs and MCs are 2.4% and 2.5%, respectively (P<1.000). Two of the PICC positive blood cultures (2/5) were related to a

PICC infection, and the other three were from other sources or probable contamination. Not all bacteremia were related to CLABSIs, and BSIs are far more common. None of the five positive cultures of MCs were caused by the line or contamination, but were from other sources, such as faces. One recent study showed that using MCs instead of central lines reduced the CLABSI rate in a ventilator unit, and midline catheters did not cause any bloodstream infections.[12]

Although it seems that patients with a MC were more likely to experience adverse events than patients with a PICC (19.5% vs 5.8%, P<0.0001), there was no significant difference between severe complications of these two devices (PICC: 4.9%, MC: 9.0%, P=0.118). MCs are associated with higher rate of non-serious complications (10.5% =(39-18)/200) as compared to PICCs (0.97% =(12-10)/206). In addition, once PICC patients have complications, they are more likely to experience severe rather than minor complications (severe/minor=10/3), while MC patients are more likely to encounter minor complications (severe/minor=18/23). The reduction of CLABSIs could be a reasonable trade of for the non-severe complications.

Among the 200 MCs, 96 had readmissions. However, none of these readmissions was caused by MC issues. A total of 49 readmissions occurred among the 206 PICCs. Four readmissions were related to PICC issues. Compared with MCs, PICCs are more likely to cause readmissions (P<0.0001). Readmission can cause extra costs for patients and penalties for hospitals.

Several reasons may account for the complication difference between PICC patients and MC patients:

- Study period (five months) and sample size (406 lines) are limited;
- PICC group (61.6% male vs. 38.4% female) and the MC group (45.4% male vs. 54.7% female) had different gender distribution (p=0.002);

- The MC group was older than the PICC group (p=0.037);
- Many patients were discharged with a PICC, and they may encounter complications after discharge. Therefore, the complications of PICCs were underestimated.

Limitations: One limitation of this study is the problem of missing data. 26% (104 PICCs and 3 MCs) of the line discontinuation data was missing because these lines were still in place at discharge, and we had difficulties getting access to the follow-up information. Incomplete documentation also accounts for the missing data. In this case, the complication rate might be underestimated. Another limitation is that the study period (January to May 2015) is relatively short compared with previous studies which had at least one year study periods.[12, 14, 18] In addition, we did not report the complications as rate per 1000 catheter days, which adjusts the dwell times of different devices and enables more reasonable comparison among different studies.[12, 14]

5.0 CONCLUSION

Based on this study, midline catheters may be a cost-efficient alternative modality to PICCs for non-irritating medication when the treatment is no longer than four weeks. As technology of these devices is evolving, longer-term data will be essential to assure safety of MCs. Additional prospective studies could more objectively assess the safety and efficacy of these two devices. The result of this study may be affected by the small sample size and short study period; therefore, further research with a large sample size and longer study period is needed to compare the safety of MCs and PICCs. We also suggest following up with patients who were discharged with a line to identify complication symptoms at an early stage. This can be done by collaboration between hospitals and other long-term healthcare facilities, using standardized documentation, and intense post-discharge surveillance.

In general, the reasons for considering MCs a better alternative to PICCs are as following:

- ✧ The reduction of CLABSIs could be a reasonable trade off for the increased non-severe complications caused by MCs.
- ✧ There were fewer readmissions due to MC issues.
- ✧ There were fewer positive blood cultures related to MC infections.
- ✧ MCs usually terminate in a large peripheral vein and far from hearts. Therefore MCs are safer than PICCs in this scenario.

APPENDIX: PICC AND MIDLINE CATHETER DOCUMENTATION

Below is the spreadsheet used for PICC and MC documentation.

Table 6. PICC and MC Documentation

PatientName	PatientMRN	Admission Date	Discharge Date	LOS	ICU Admission Date	ICU Discharge Date	ICU LOS	Age	Gender	Admitting Diagnosis	Deceased	Deceased Date	Charlson CI

PatientName	PatientMRN	Unit Where Line Was Placed	Reason for Insertion	Insertion Site	Gauge	Insertion Date	Discontinue Date	PICC/MC Duration	DischargedWithPICC	Reason for discontinuation	Date of Culture	Culture source	Pathogen Related to Infection

PatientName	PatientMRN	Readmisson	Num. of Additional lines	Line Type 1	Line Type 2	Line Type 3	Line Type 4	Comments	DVT

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