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Central Vascular Access Device Complications in Pediatric Home Care Patients Managed by Family Caregivers or Nurses

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ABSTRACT

There is a paucity of data regarding complications and outcomes of central vascular access devices (CVADs) in pediatric home care patients. Unlike hospital and clinic settings, home care patients commonly receive catheter care and accesses by family caregivers rather than nurses. This 2-year prospective study compared complications and outcomes of 222 CVADs managed by nurses or family caregivers. CVADs were followed for skin complications at insertion site, catheter complications, central line–associated bloodstream infection occurrences, and the outcome of dysfunctional catheters treated with alteplase. Results showed no differences in any CVAD complications, whether access and care were primarily performed by trained family caregivers or nurses.

Key words: central vascular access device, central venous catheter, complications, home care, outpatients, pediatric

Access to home intravenous (IV) therapy for children has been demonstrated to be effective and safe.[1] This strategy also decreases costs and hospital length of stay. Infusion therapies for pediatric outpatients include, but are not limited to, chemotherapy, hydration, total parenteral nutrition (TPN), enzyme replacement therapy, inotropes,[2] gamma globulin, analgesics, and antibiotics. Additionally, venipuncture in children with chronic medical conditions is often difficult and traumatic. The presence of a central vascular access device (CVAD) provides easy access for obtaining blood specimens during home visits. Pediatric studies that examine complications associated with central catheters are predominately composed of hospitalized children[3,4] or immunosuppressed pediatric outpatients.[5] Catheter access is commonly performed by professional caregivers in these settings. Commonly in pediatric home care, family caregivers perform most of the catheter accesses after instruction.

Complications and outcomes of CVADs in pediatric home care patients have been inadequately studied.[6] Generally, children in home care are more active than hospitalized patients. Consequently, risk factors for CVAD complications in pediatric home care patients could differ, because hospitalized children may be less mobile and have complicating comorbidities, and CVAD access is limited to professional nursing staff. Although it is largely unknown if CVAD management by family caregivers is a risk factor for complications, proper training has been shown to decrease central line–associated bloodstream infection (CLABSI) rates.[7,8] This study documented complication rates of CVADs in pediatric home care patients and compared whether family caregivers, in lieu of nurses accessing CVADs, were a risk factor for adverse outcomes.

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METHODS

Study Design and Data Collection

This was a 2-year prospective observational study of complications and outcomes of CVADs in pediatric home care patients referred to a pediatric home infusion company. The study was conducted between October 1, 2014, and September 31, 2016. The CVAD was the primary observation. Patients with regular nursing visits had data collection concomitant with visits. Patients not requiring nursing visits received phone calls based on the frequency of catheter therapy to collect data. Data were collected prospectively with a collection tool and entered by a single researcher into a database (Table 1). CVAD outcome measures were followed from the date the catheter was established until removal or the end of study. For patients with existing catheters, data were collected from date of signed consent. Parents or guardians gave informed consent for subjects ≤18 years of age. This study was approved by the Children's Minnesota Institutional Review Board.

Study Population

Initially 246 CVADs were identified, but 24 were eliminated due to unreliable data and frequent hospitalizations. Subsequently, 222 CVADs were followed in the study among 186 pediatric home care patients. Inclusion criteria were composed of infusion patients <21 years of age, followed by a home infusion nurse with signed consent. Patients with unreliable data, no signed consent, or not followed by a home infusion nurse were excluded. Primary diagnosis and indication for CVAD placement were identified. Patient education by the home care company included CVAD problems. This covered catheter complications at the skin/insertion site, complete or partial occlusion, and potential for CLABSI. Infusion nurse training of caregivers was followed by hands-on return demonstration. Educational documents (with proprietary video links) were provided and reinforced with follow-up phone calls and visits (see Supplement Digital Content 1, http://links.lww.com/JIN/A100).

TABLE 1

Tool for Calculating Catheter Accesses

Therapy	Frequency	Total access per day	Therapy days	Total accesses
Line care	Daily	2	48	96
	Every 12 h	4	49	196
PORT flush	Monthly	2	12	24
TPN continuous	Daily	2	471	942
TPN cyclic	Twice daily	4	143	572
Antibiotic	Daily	4	13	52
	Daily with another abx	3	14	42
	Every 12 h	8	20	160
	Every 8 h	12	7	84
	Every 6 h	15	15	225

Abbreviations: abx, antibiotic; PORT, vascular access port; TPN, total parenteral nutrition.
This table shows examples of how catheter accesses were calculated.

Outcome Measures

CVADs were followed for skin complications at insertion site, catheter complications, CLABSI occurrences, and outcome of dysfunctional catheters treated with alteplase. The definition of CLABSI was derived from the Centers for Disease Control and Prevention, "A laboratory confirmed bloodstream infection (BSI) where an eligible BSI organism is identified and an eligible central line is present on the laboratory confirmed BSI on the day of the event or the day before."[9] For purposes of this study, the catheter complication dislodgment (partial or complete) refers to peripherally inserted central catheters (PICCs) or tunneled catheters. Implanted vascular access port-associated problems were listed under dysfunction.

Catheter Access

CVADs were divided into 2 cohorts (family caregivers or nurses) regarding catheter access. To qualify for this analysis, >60% of catheter accesses had to be performed by the ascribed cohort, but in general, >90% of all CVAD accesses were performed by family caregivers or nurses in their respective grouping. Catheter accesses were estimated based on the daily frequency of IV therapy, accesses per day, duration of therapy, and parental feedback. CVADs with indeterminate or unreliable data or that did not meet inclusion criteria were excluded from analysis.

Statistical Analysis

Descriptive information about the observed catheters was determined from record reviews and reported as the percentage of observed catheters. A χ^2 analysis was used to test the association between skin or catheter complications and the occurrence of a CLABSI. The χ^2 test was also used to analyze the association between different CVADs and any type of catheter complication. A P value of $< .05$ was identified a priori as the level of significance. Time to CLABSI was plotted for catheters with a CLABSI occurrence.

The χ^2 test examined the association among CLABSI occurrences, catheter, or skin complications and access at a level of >60% by family caregivers versus nurses. For this analysis, an adjusted P value of $< .005$ was used to account for multiple test error.

RESULTS

Patient Demographics

There were 222 CVADs among 186 patients (Table 2). Enrolled patients tended to be younger, with 57.7% of patients ≤10 years of age. PICCs were the predominant catheter type, followed by vascular access ports and tunneled catheters. Heparin, alone or in combination, was

TABLE 2

Patient Demographics

	All CVADs (n = 222)		CVADs without CLABSI (n = 205)		CVADs with CLABSI (n = 17)	
	n	%	n	%	n	%
Age, y						
< 1	17	7.7%	16	7.8%	1	5.9%
1–5	60	27.0%	53	25.9%	7	41.2%
6–10	51	23.0%	47	22.9%	4	23.5%
11–15	59	26.6%	57	27.8%	2	11.8%
16–21	35	15.8%	32	15.6%	3	17.6%
Gender						
Female	112	50.5%	100	48.8%	12	70.6%
Male	110	49.5%	105	51.2%	5	29.4%
Race						
White	160	72.1%	146	71.2%	14	82.4%
Other/not reported	62	27.9%	59	28.8%	3	17.6%
Line type						
PICC	104	46.8%	103	50.2%	1	5.9%
PORT	67	30.2%	59	28.8%	8	47.1%
Tunneled	50	22.5%	43	21.0%	7	41.2%
Other	1	0.5%	0	–	1	5.9%
Lock type						
Ethanol	3	1.4%	2	1.0%	1	5.9%
Heparin	194	87.4%	180	87.8%	14	82.4%
Saline	8	3.6%	8	3.9%	0	–
tPA	1	0.5%	0	–	1	5.9%
Heparin combination	16	7.2%	15	7.3%	1	5.9%
Primary diagnosis						
Cardiac	10	4.5%	9	4.4%	1	5.9%
Intestinal failure/short bowel syndrome	38	17.1%	32	15.6%	6	35.3%
Immunodeficiency	17	7.7%	17	8.3%	0	–
Inborn error/metabolic	8	3.6%	6	2.9%	2	11.8%
Infection	76	34.2%	75	36.6%	1	5.9%
Malignancy	18	8.1%	16	7.8%	2	11.8%
Neuromuscular	12	5.4%	11	5.4%	1	5.9%
Renal	1	0.5%	0	–	1	5.9%
Respiratory	22	10.0%	22	10.7%	0	–
Transplant (stem cell, BMT, solid organ)	6	2.7%	5	2.4%	1	5.9%
Other	14	6.3%	12	5.9%	2	11.8%
Congenital syndrome/chromosomal abnormality	90	40.5%	78	38.0%	12	70.6%
Indication for line placement						
Antibiotics	124	55.9%	117	57.1%	7	41.2%
Chemotherapy	9	4.1%	8	3.9%	1	5.9%
Immunotherapy	19	8.6%	19	9.3%	0	–
IV access/hydration/blood draws	57	25.7%	50	24.4%	7	41.2%
TPN	38	17.1%	31	15.1%	7	41.2%
Other	26	11.7%	22	10.7%	4	23.5%

Abbreviations: BMT, bone marrow transplant; CLABSI, central line-associated bloodstream infection; CVAD, central vascular access device; IV, intravenous; PICC, peripherally inserted central catheter; PORT, vascular access port; tPA, tissue plasminogen activator; TPN, total parenteral nutrition.

TABLE 3

Skin Complications and Association with CLABSI

	All patients (n = 222)		Patients without CLABSI (n = 205)		Patients with CLABSI (n = 17)		
	n	%	n	%	n	%	*P* value
Drainage	25	11.3%	21	10.2%	4	23.5%	NS[a]
Skin breakdown	12	5.4%	9	4.4%	3	17.6%	.02
Rash	18	8.1%	15	7.3%	3	17.6%	.007
Erythema	19	8.6%	14	6.8%	5	29.4%	.001
Infiltration	10	4.5%	7	3.4%	3	17.6%	NS[a]

Abbreviation: CLABSI, central line-associated bloodstream infection.
[a]NS, not significant at the .05 level.

used as the catheter lock in 94.6% of CVADs. Referrals for home infusion commonly included children with medical complexity (CMC), and our study identified that 40.5% of enrolled patients had a congenital syndrome and/or a chromosomal abnormality (cystic fibrosis excluded). The most common diagnosis for treatment was infection followed by intestinal failure/short bowel syndrome. Respiratory was the third most common diagnosis and included cystic fibrosis encounters. There were often multiple indications for CVAD placement, but the most common therapies were antibiotics, TPN, and IV access for blood draws or hydration.

Skin Complications

The study population was monitored for the following at the insertion site: drainage, skin breakdown, rash, erythema, and infiltration. At least 1 of the 5 skin complications (Table 3) occurred at the insertion site in 45 (20.2%) of 222 CVADs . In 7 (15.6%) of 45 CVADs with a skin complication, all 5 of the skin complications were present. Drainage was the most common skin complication followed by erythema. A greater proportion of catheters with CLABSI also reported at least 1 skin complication ($P = .03$). The following skin complications were associated with CLABSI: skin breakdown, rash, and erythema.

CVAD Complications

One or more complications occurred in 71 (32%) of 222 CVADs, and most were associated with catheter dysfunction related to infusion or blood sampling (Table 4). Dislodgement occurred in 10 (4.5%) of 222 CVADs. The presence of a CVAD complication was associated with a CLABSI for the following complications: sluggish, no blood return, phlebitis, venous thrombosis, and leak. Premature removal due to dysfunction occurred in 19 (8.6%) of 222 catheters: PICCs (n = 4), vascular access ports (n = 4), and tunneled catheters (n = 11). Premature removal for all causes occurred in 7 (6.7%) of 104 PICCs and was due to dysfunction (n = 4), dislodgement (n = 2), and infection (n = 1).

TABLE 4

CVAD Complications and Association with CLABSI

	All patients (N = 222)		Patients without CLABSI (n = 205)		Patients with CLABSI (n = 17)		
	n	%	n	%	n	%	*P* value
Dislodgement	10	4.5%	8	3.9%	2	11.8%	NS[a]
Occlusion	17	7.7%	14	6.8%	3	17.6%	[b]
Sluggish	36	16.2%	27	13.2%	9	52.9%	.001
No blood return	42	18.9%	34	16.6%	8	47.1%	.002
Phlebitis	7	3.2%	5	2.4%	2	11.8%	.03
Venous thrombosis	7	3.2%	5	2.4%	2	11.8%	.03
Leak	7	3.2%	5	2.4%	2	11.8%	.03
Other	18	8.1%	14	6.8%	4	23.5%	NS[a]

Abbreviations: CLABSI, central line-associated bloodstream infection; CVAD, central vascular access device.
[a]NS = not significant at the .05 level.
[b]See section on alteplase.

TABLE 5

Characteristics of CLABSI-Associated Catheters (n = 17)

	N	%
Line type		
PICC	1	5.9%
PORT	8	47.1%
Tunneled	7	41.2%
Other	1	5.9%
Lock type		
Ethanol	1	5.9%
Heparin	14	82.4%
Saline	0	–
tPA	1	5.9%
Heparin combination	1	5.9%
Entry point of line		
Chest	14	82.4%
Groin/lower extremity	1	5.9%
Neck	1	5.9%
Upper extremity	1	5.9%
Dwell time		
<30 d	4	23.5%
30–60 d	0	–
61–180 d	4	23.5%
181–365 d	4	23.5%
366–720 d	4	23.5%
>720 d	1	5.9%

Abbreviations: CLABSI, central line-associated bloodstream infection; PICC, peripherally inserted central catheter; PORT, vascular access port; tPA, tissue plasminogen activator.

CLABSI Occurrences and Pathogens

Characteristics of the 17 CLABSIs that were documented in 222 catheters (7.7%) are shown in Table 5, and approximately 50% of CLABSIs occurred within 6 months of catheter placement (Figure 1). There were 48 223 total catheter days accounting for a CLABSI rate of 0.35/1000 catheter days. Due to small numbers, only the following complications (dislodgement, occlusion, sluggish, no blood return, or other) could be tested in association with any type of CVAD. Tunneled catheters and vascular access ports had a greater association with CLABSI than PICCs ($P = .001$).

Coagulase-negative staphylococcus was the predominant organism and associated with 35.3% of CLABSIs (Table 6), and 3 of 17 were polymicrobial. Intestinal failure/short bowel syndrome was the only diagnosis statistically associated with CLABSI ($P = .04$), and 6 (35%) of 17 reported CLABSIs were identified with that diagnosis (Table 2). A syndrome and/or chromosomal abnormality was associated with 12 (70.6%) of the 17 CLABSIs.

Alteplase

Dysfunctional CVADs were categorized as occlusion, sluggish, or no blood return. Catheters could have more than 1 of each of these attributes. Alteplase was administered at least once in 38 (17.1%) of 222 catheters, for a total of 80 infusions. The occlusion rate per 1000 catheter days requiring alteplase was 0.78, and doses of alteplase per 1000 catheter days were 1.66. A comparison of outcomes for dysfunctional catheters pre- and post-alteplase treatment was recorded (Tables 7A and 7B, respectively). Occlusion was associated with a significantly greater proportion of tunneled catheters than PICCs or vascular access ports ($P = .001$) (Table 7A). Despite alteplase treatment, occlusion persisted in 8 (88.9%) of 9 occluded catheters. Catheters reported as sluggish or no blood return demonstrated improved function following alteplase in 15 (65%) of 23 and 17 (73.9%) of 23, respectively. A CLABSI was associated with 3 (13.2%) of 38 dysfunctional catheters. Ultimately the need for alteplase treatment was associated with premature CVAD removal in 17 (44.7%) of 38, and 9 (53%) of 17 of these catheters were used for TPN infusions. Of alteplase-treated catheters used for TPN infusions, 73% were tunneled catheters. There was no statistically significant association between CVAD type and alteplase administration.

Catheter Access by Family Caregiver or Nurse

Pediatric home care infusion patients' CVADs were predominantly accessed by family caregivers after supervised training. As expected in a pediatric home care population, catheter access was heavily weighted toward family caregivers (Table 8). Of the 222 CVADs, 138 (62.2%) were accessed ≥60% of the time by family caregivers, and 58 (26.1%) were accessed ≥60% of the time by nurses. For this analysis, 26 CVADs with indeterminate accesses were excluded for not meeting inclusion criteria. In the family caregiver group, there were 132 of 138 catheters in the family caregiver cohort and 55 of 58 catheters in the nurse cohort that had reliable data to estimate a total of 68 104 accesses to use for this analysis. Family caregivers performed 76.3% (51 944/68 104) of catheter accesses, and nurses performed 23.7% (16 159/68 104) of catheter accesses. CLABSI, skin, and catheter complications were compared between catheters, whether accessed predominantly by family caregivers or by nurses (home care, clinic, and hospital). There were no statistically significant differences at the P value $< .005$ level (defined priori for multitest error analysis) in CLABSI, skin, or catheter complications between the 2 groups.

DISCUSSION

Pediatric CVAD Overview

Central catheters are generally divided into 3 categories: (1) percutaneously inserted nontunneled (PICC) or centrally

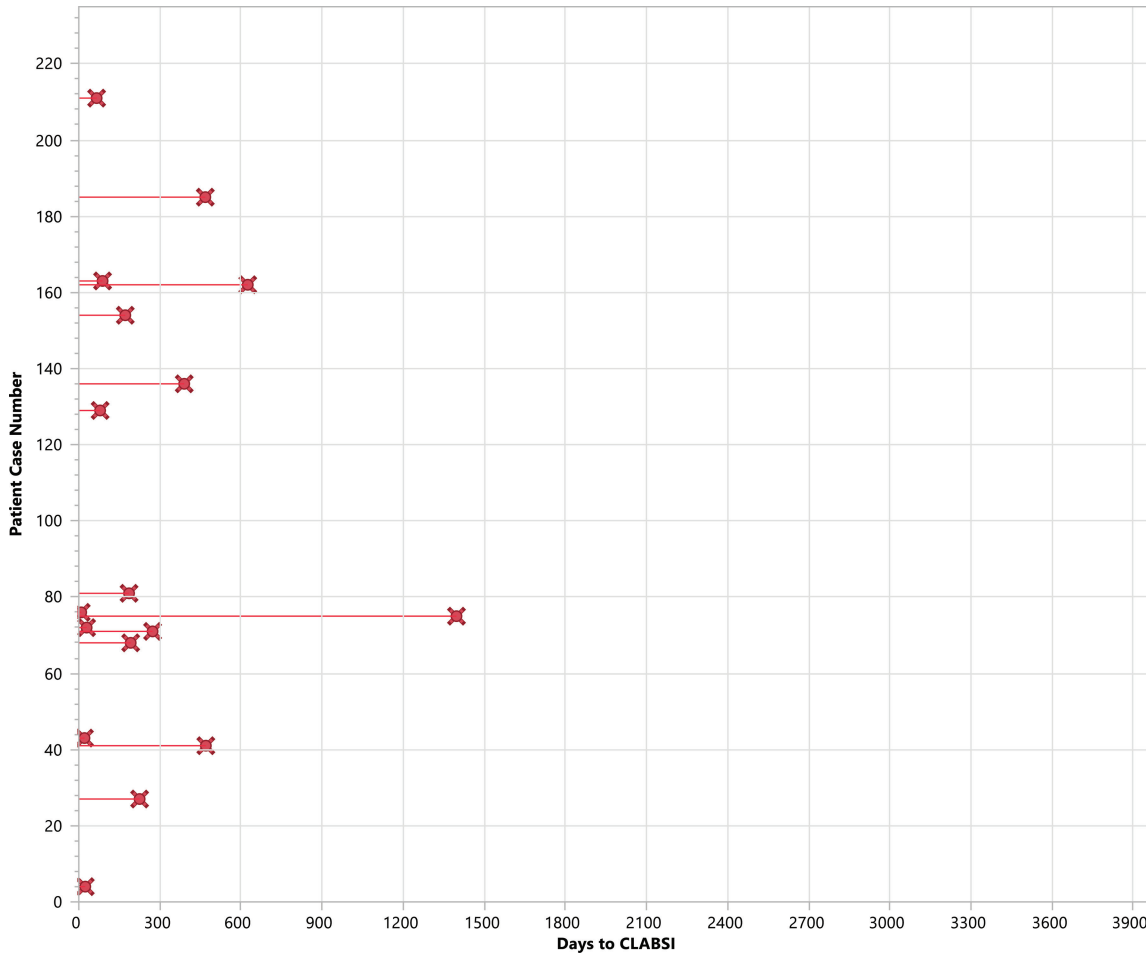

Figure 1 Event plot—time to CLABSI (n = 17). *Abbreviation: CLABSI, central line-associated bloodstream infection.*

placed nontunneled CVAD, (2) tunneled catheters, and (3) implantable devices (vascular access ports). These different types of catheters, except for centrally placed nontunneled CVADs, are used to manage pediatric outpatients. Independent of the type of catheter, access is generally performed by a nurse in an outpatient clinic or hospital setting. In home care, however, family caregivers are trained to access and care for their child's CVAD. There are limited studies on the incidence and outcome of CVAD complications in pediatric home care patients; however, in hospitalized children, CVAD complications such as CLABSI will increase costs and length of stay.[10] To fill the gap in our understanding of outcomes for CVADs in children receiving home infusions, our study focused on complications of CVADs in a pediatric home care population.

There may be an increase in prevalence of CVADs to manage children in community settings, and 7% of children's hospital discharges go home with a CVAD.[11] Currently, CVADs are the third most common medical device to contribute to an emergency department encounter for CMC.[12] Reviews of pediatric CVADs commonly focus on PICCs.[13] PICCs can often be inserted without anesthesia or the need for an operating room. Short-term therapies and easy removal may also account for why PICCs were the most common CVADs in this study. As with hospitalized children,[4] our study identified that the most common diagnosis for catheter placement was infection-related antibiotic therapy. Postsurgical wound infections, osteomyelitis, and cystic fibrosis exacerbations predominated as infection-related diagnoses.

The second most common diagnosis associated with CVAD placement was intestinal failure/short bowel syndrome providing TPN and IV hydration for enrolled home infusion patients. Our study also separately characterized any secondary diagnoses that included syndromes or chromosomal abnormalities. Previously unreported in pediatric home care patients, the findings established that 40.5% of CVADs were associated with a congenital syndrome and/or chromosomal abnormality, and these descriptors were linked with 12 (70.6%) of the 17 CLABSIs.

Skin Complications

Reviews of pediatric CVADs uncommonly report skin complications at catheter entry site. To address this, skin complications were stratified into 5 categories based on signs and symptoms, not diagnosis. In this study, 20% of CVADs had at least 1 skin complication. Drainage at the insertion site was the most common complication, followed

TABLE 6

CLABSI Pathogens

Organism(s)	Incidence	Percentage
Candida albicans	1	5.9%
Enterobacter cloacae	1	5.9%
Enterobacter; diphtheroid	1	5.9%
Klebsiella pneumoniae	1	5.9%
Micrococcus	1	5.9%
Pseudomonas aeruginosa	1	5.9%
*Pseudomonas aeruginosa/ Citrobacter*species	1	5.9%
Serratia marcescens	1	5.9%
Staphylococci coagulase negative	5	29.4%
Staphylococcus coagulase negative; *Lactococcus garvieae; Candida lusitaniae*	1	5.9%
Stenotrophomonas (Xanthomonas) maltophilia	2	11.8%
Viridans group streptococci	1	5.9%

Abbreviation: CLABSI, central line-associated bloodstream infection.

by erythema. In comparison with a study in hospitalized children that identified skin complications in 14% of CVADs (drainage not listed), the most common sign and diagnosis were erythema and contact dermatitis, respectively.[14] The contribution of a medical adhesive-related skin injury to skin complications was not specifically determined in our study but has been reported as a significant risk factor for adults.[15] An additional finding in our study was that skin breakdown, erythema, or rash at entry site was statistically associated with a CLABSI. To prevent CLABSI, incorporating entry site care has been an important facet of CVAD bundles and is equally important in home care patients with best practices, as outlined previously.[16] The company's home infusion nurses follow and instruct on the *Infusion Therapy Standards of Practice* for CVAD care and access.[17]

CVAD Complications

Children referred for home infusion services are a diversified population with different catheter types and needs. This study compared outcomes for different types of CVADs recognizing that PICCs predominated in enrolled patients. Most CVAD complications in children address PICCs, with complications reported as 20% to 50%.[4]

In a hospital setting, a comparison of CVADs in pediatric patients found a higher incidence of CLABSI and venous thromboembolism in PICCs[18] compared with only 1 (5.9%) of 17 CLABSIs in the current study. These findings also found a lower complication rate in PICCs compared with tunneled central catheters or vascular access ports, as described previously.[19] Supporting our findings, a comparison of CVADs in pediatric intensive care units found that PICCs also had a lower CLABSI rate.[20] On occasion, infected or dysfunctional CVADs required early removal. Complications necessitating catheter removal with PICCs range between 8%[21] and 20%.[4] Among PICCs in this current study, 6.7% required

TABLE 7A

Dysfunctional CVAD Pre-alteplase

	Occlusion (11/48)		Sluggish (n = 24/48)		No blood return (29/48)	
Type of catheter	N	% (n = 11)	N	% (n = 24)	N	% (n = 12)
Tunneled (single or double)	7	63.6%	9	37.5%	10	34.5%
PICC (single or double)	2	18.2%	10	41.7%	9	31.0%
PORT (single or double)	2	18.2%	5	20.8%	10	34.5%
Dialysis catheter	0	–	0	–	0	–

Abbreviations: CVAD, central vascular access device; PICC, peripherally inserted central catheter; PORT, vascular access port.

TABLE 7B

Dysfunctional CVAD Post-alteplase

	Occlusion (15/48)		Sluggish (n = 13/48)		No blood return (12/48)	
Type of catheter	N	% (n = 15)	N	% (n = 13)	N	% (n = 12)
Tunneled (single or double)	11	73.3%	8	61.5%	7	58.3%
PICC (single or double)	1	6.7%	3	23.1%	1	8.3%
PORT (single or double)	3	20.0%	2	15.4%	4	33.3%
Dialysis catheter	0	–	0	–	0	–

Abbreviations: CVAD, central vascular access device; PICC, peripherally inserted central catheter; PORT, vascular access port.

TABLE 8

Catheter and Skin Complications by Family Caregiver or Nurse Access ≥60%

	Family caregiver access ≥ 60% (n = 138)		Nurse access ≥ 60% (n = 58)		
	No. of lines	% of lines	No. of lines	% of lines	*P* value
Infection					
CLABSI	7	5.1	4	6.9	.6125
Skin complications					
Drainage	14	10.1	2	3.4	.1285
Skin breakdown	4	2.9	1	1.7	.6527
Rash	10	7.2	0	–	.0294[a]
Erythema	11	8.0	1	1.7	.1031
Infiltration	1	0.7	2	3.4	.1475
Catheter complications					
Dislodgement	2	1.4	1	1.7	.8681
Occlusion	4	2.9	5	8.6	.0724
Sluggish	18	13.0	10	17.2	.3983
No blood return	19	13.8	13	22.4	.1131
Phlebitis	0	–	0	–	Not tested
Venous thrombosis	0	–	0	–	Not tested
Leak	0	–	0	–	Not tested
Other	6	4.3	1	1.7	.3817

Abbreviation: CLABSI, central line-associated bloodstream infection.
[a]Fisher's exact test; not suggested using *P* value = .005, adjusted for multiple test error.

premature removal. Catheter complications may differ within pediatric populations, and in children with cancer receiving parenteral nutrition,[22] vascular access ports had worse outcomes with CLABSI and occlusion. Hospitalized children reportedly have higher CLABSI rates than those managed as outpatients, and for pediatric hematology/oncology patients, this is independent of catheter type.[23] An increased propensity for complications, like CLABSI, may be related to underlying comorbidities or inadequate training of staff.[24] After analyzing all of the catheters, the current study found a CLABSI rate of 0.35/1000 catheter days in the company's home care population, which is lower than reported rates for hospitalized children.

CVAD Occlusion

Inability to infuse or draw blood from a catheter is a known complication, and occluded CVADs may result in up to 20% requiring removal.[25] Regarding CVAD dysfunction in home infusion, thrombotic occlusion is the principal cause.[26] A study in children found that 12% of CVADs ultimately required alteplase treatment for catheter malfunction,[27] compared with 17% in the current study. These findings identified an occlusion (0.78) and alteplase (1.66) dose rate per 1000 catheter days that aligns with a previous report in pediatric patients (0.26–1.59 and 0.26–1.80, respectively).[6]

Alteplase is used to treat occluded catheters with variable success. Use of alteplase to restore function in dysfunctional tunneled catheters in children was associated with an 88% success rate.[28] A review on alteplase administration in children with occluded CVADs identified an overall efficacy in 50%–90% of occluded CVADs.[29] In the current study, occluded catheters often failed to respond to alteplase infusion, but success rates were better for CVADs that were sluggish or had no blood return. Delay in administration of alteplase is associated with a lower success of improvement in restoring catheter function[30] and may account for our findings in a home care population without timely access to thrombolytics. Also, nonthrombotic occlusions due to lipids, mineral, or drug precipitation[31] may account for lower response rates to alteplase. Nonthrombotic occlusion and precipitation may have contributed to the findings in the current study. These findings identified that 53% of catheters that failed alteplase treatment, and subsequently required premature removal, were associated with TPN infusion. The only clearance agent used in this study was alteplase. This finding was corroborated by a report on CVADs in pediatric patients with intestinal failure, identifying frequent complications and shorter lifespans.[32] The current study also found that the need for alteplase treatment was associated with a risk for CLABSI, as has been described previously.[27]

CVAD Access

Family caregiver training for accessing and managing CVADs has been shown to decrease CLABSI rates in children with intestinal failure[8] and leukemia.[7] Conversely, a high turnover of nurses caring for patients with CVADs was associated with an increase in catheter-related infections.[24] To our knowledge, there are no studies comparing outcomes between CVADs managed by family caregivers versus nurses as a risk factor for catheter complications. Although most catheter accesses in the current study were performed by family caregivers, a comparison to predominantly nurse-accessed CVADs failed to find any statistically significant difference in any outcome measure or complication. Several factors could influence this finding. During the study period there was a low turnover of infusion nurses. Consequently, dedicated home infusion nurses communicate a consistent message to families regarding safety and care of catheters. A partnership between nurses and family caregivers includes sharing training material with access to proprietary videos for managing CVAD (see Supplemental Digital Content 1, http://links.lww.com/JIN/A100). From the perspective of parents of CMC educated in the care of their child, they are skilled caregivers providing complex care at home.[33]

LIMITATIONS

One of the limitations of this study is that it involved a single pediatric home care company with a relatively small sample size relative to hospital-based studies. This restricted analysis of observations among the 3 different catheter types. There is a lack of published literature involving only pediatric home care patients for comparing outcomes with the current study. Associating outpatient studies to a pediatric home care population may be erroneous. Outpatient therapies often occur through hospital or clinic-based facilities, potentially a different population, and interventions commonly performed by nurses.

CONCLUSIONS

Pediatric home care patients are a diverse group and often include children with chromosomal abnormalities and/or syndromes. As with hospitalized children, the primary indication for CVAD insertion in pediatric home care patients was for antibiotic therapy for an established infection. Skin complications are rarely reported in pediatric CVAD studies, but the current study found that a skin complication occurred in 20% of CVADs. Drainage, erythema, and rash at insertion site were risk factors for development of a CLABSI. A CVAD complication occurred in one third of CVADs, and, characteristically, this was associated with catheter dysfunction. The need for alteplase treatment for a dysfunctional catheter ultimately resulted in nearly half of treated CVADs being removed prematurely. Family caregivers, in lieu of nurses accessing CVADs, were not associated with an increased risk of any catheter complication. Additional research is warranted to identify whether complication rates with CVAD differ between pediatric home care patients and their hospitalized counterparts due to a higher illness acuity in the latter.

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