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Medically Attended Catheter Complications are Common in Patients with Outpatient Central Venous Catheters

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Abstract

Objective—Outpatient central venous catheters (CVC) are being used more frequently, however data describing mechanical complications and central line-associated bloodstream infections (CLABSI) in the outpatient setting are limited. We performed a retrospective observational cohort study to understand the burden of these complications to elucidate their impact on the healthcare system.

Methods—Data were retrospectively collected on patients discharged from Vanderbilt University Medical Center with a CVC in place and admitted into the care of Vanderbilt Home Care Services. Risk factors for medically attended catheter associated complications (CAC) and outpatient CLABSIs were analyzed.

Results—A CAC developed in 143 (21.9%) patients, totaling 165 discrete CAC events. Of these, 76 (46%) required at least one visit to the emergency department or an inpatient admission, while the remaining 89 (54%) required an outpatient clinic visit. The risk for developing a CAC was significantly increased in female patients, patients with a CVC with more than one lumen, and patients receiving total parenteral nutrition. The absolute number of CLABSIs identified in the study population was small at 16 or 2.4% of the total cohort.

Conclusion—Medically attended catheter complications were common among outpatients discharged with a CVC and reduction of these events should be the focus of outpatient quality improvement programs.

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Conflicts of Interest. The authors have nothing to disclose

Introduction

An increasing number of medical conditions are being treated in the outpatient setting. In addition, the use of outpatient infusion therapies via central venous catheters (CVC) has increased in order to discharge patients from the hospital, address patient convenience, improve cost-effectiveness and potentially reduce risk from hospital-acquired harm.[1] Data describing mechanical complications and central line-associated bloodstream infection (CLABSI) rates related to outpatient CVCs are limited. Applying traditional CLABSI surveillance methods to outpatient settings can be very challenging, including the capture of signs and symptoms of an infection and the calculation of device days. The published data detailing the burden of CLABSI in outpatient settings have noted lower CLABSI rates when compared to inpatient infection rates.[2,3] This observation likely reflects a larger device day denominator, as patients in the outpatient setting tend to have longer catheter dwell times. Even with lower rates, the absolute number of events are substantial.[2,4] In addition, such patients are at risk for other medically attended catheter associated complications (CAC), such as infusate toxicity, loss of catheter patency, and other mechanical and thrombotic complications.[5–8] Descriptions of the burden of these CACs in outpatients with a CVC are limited.

It is important to understand the burden of these CACs and the risk of outpatient CLABSI to elucidate the true impact of these events. We performed a retrospective observational cohort study in the population of patients with a CVC discharged from a tertiary care medical center (Vanderbilt University Medical Center [VUMC]) who received outpatient CVC care through the primary VUMC home care affiliate, Vanderbilt Home Care Services (VHCS).

Methods

Study Population

Data were retrospectively collected on patients discharged from VUMC with a CVC in place and admitted into the care of VHCS. VUMC is a tertiary, university-affiliated medical center where over 55,000 adult and pediatric patients are admitted annually. There are approximately 1,000 patients discharged from VUMC requiring CVC infusion services annually, and over 80% of these patients are referred to VHCS for CVC care.

All adult and pediatric patients who were discharged from VUMC with a CVC in place and who had home health skilled nursing provided by VHCS between July 1, 2012 and September 30, 2013 were eligible for inclusion. Eligible patients were identified using current procedural terminology (CPT) codes that denoted insertion of a CVC during the hospitalization and associated VHCS electronic clinical documentation that indicated post-discharge skilled nursing visits for infusion therapy had been performed (for CPT codes used, see appendix). A CVC was defined as either a catheter or subcutaneous port with the proximal catheter tip located in a central vein, i.e. the superior vena cava or the inferior vena cava. Patients with the presence of a CVC on discharge, but no record of care via VHCS were excluded from the study population.

Risk Factors

A full chart review was performed once CVC presence was verified. The chart includes outpatient medical records within the Vanderbilt system or affiliates. Data abstracted consisted of patient characteristics including age, sex, history of organ transplantation (solid or hematologic), neutropenia (absolute neutrophil count < 500 per microliter) at time of CVC insertion, recent chemotherapy for cancer (within 4 weeks of CVC insertion), diagnosis of chronic inflammatory bowel disease (e.g., Crohn's disease, ulcerative colitis, celiac disease, etc.), or prescription for an immune suppressant (for list, see appendix). CVC characteristics collected included documented indication for the CVC, anatomic (vascular) location, type of catheter (peripherally inserted, subcutaneous port, centrally inserted non-tunneled or tunneled, number of lumens), and frequency of line access per day while outpatient. The frequency of daily access of the CVC was determined by the infusate order (e.g. ertapenem once daily equals CVC accessed once daily, cefepime every 8 hours equals thrice daily). Information regarding post-discharge healthcare encounters within the medical center was also collected. CVC removals were not documented by VHCS or the supervising provider in way that could be abstracted, and thus line days were not included in the analysis.

Outcomes

The primary study outcome was the frequency of CACs, defined as a complication heralded by an unexpected medical visit to an outpatient clinic, emergency department (ED) or inpatient admission, where the complication was related to the CVC or infusion therapy. Outpatient CLABSI was defined utilizing the National Healthcare Safety Network (NHSN) definition of CLABSI as described in January 2014 protocols with a modified timeframe shifting the date of event to be on or after day 3 of discharge to identify events in the outpatient setting.[9,10] One investigator (SS) reviewed each case and ascertained the presence of an outpatient CLABSI. Common procedure for VHCS was to direct any patient to the ED if the home health nurse elicited any signs or symptoms of sepsis and thus we were able to abstract data on possible infections from the ED or outpatient clinic visits.

CVC Insertion Procedures

The insertion of all the peripherally inserted central catheters (PICC) at VUMC is performed by a specially trained procedure nurse or an interventional radiologist. The decision of which peripheral vein to access is typically made by the proceduralist; however, the decision for type of line and number of lumens is initiated by the ordering provider in consultation with the procedure team. The subcutaneous ports and centrally inserted CVCs were placed by an interventional radiologist or a surgeon (typically a vascular, pediatric, or general surgeon). These were placed in either the subclavian or internal jugular veins at the proceduralist's preference.

Statistical Analysis

Differences in the proportion of patients in risk factor groups by each binary outcome were assessed by χ^2 test. Adjusted odds ratios (OR) and associated 95% confidence intervals (95% CI) for risk-factor-outcome associations were generated by multivariable logistic

regression models with robust variances. Age was modeled using a restricted cubic spline with 4 knots to allow non-linearity in the age-outcome relationship.[11]

Results

During the study period, a total of 740 CVCs were used in 654 unique patients. This cohort was 53.4% male, with a median age of 44 years. The majority of CVCs were indicated for OPAT (74.0% of the patients), but some were placed for delivery of chemotherapy (15.0%) and total parenteral nutrition (TPN, 6.6%). PICCs were used for a majority (82%) of the patients, while the rest had subcutaneous ports (11.7%), tunneled CVCs (3.5%), and non-tunneled centrally inserted CVCs (2.9%). The majority of PICCs (97.7%) were placed in the basilic or brachial veins, and only 12 (2.3%) were placed in the cephalic veins.

The majority of patients (53.4%) were accessing their CVCs once daily or less frequently; however, 27.8% were accessing their CVCs three or more times daily, and 5% were accessing it 5 times a day.

Description of the primary outcome, CACs

A CAC developed in 143 (21.9%) of the patients, totaling 165 CACs. Of these, 76 (46%) required at least one visit to the ED or an inpatient admission, while the remaining 89 (54%) required an outpatient clinic visit. The frequency of specific types of CACs are noted in Table 2. Sixty CACs or over 36% of all CACs, were due to a loss of CVC patency and almost 10% were related to an outpatient CLABSI. Notably, 14.3% of patients with a CAC ultimately needed a new catheter placed.

Among the 60 CACs with loss of patency, 31 resolved with tissue plasminogen activator (tPA) administration, and 29 ultimately required a new CVC. Among the 76 CACs requiring an ED or inpatient admission, 54 were due to a suspected infection, but only 16 ultimately met the definition of an outpatient CLABSI. Among the CACs that required an outpatient clinic visit, all 89 were due to a loss of patency or other mechanical complication (as listed in Table 2 footnotes).

Risk factors for CACs

In the regression analysis, patients with TPN as an indication for CVC were significantly more likely to develop a CAC compared to those with OPAT as an indication (odds ratio [OR]= 4.27, 95% CI: 1.75–10.41, $p<0.01$). Forty-two percent of the 43 study patients with a CVC indication of TPN developed a CAC and 9.3% developed a CLABSI. Of the 98 patients with chemotherapy as the CVC indication, 20.4% developed a CAC and 4.1% developed a CLABSI.

The risk for developing a CAC significantly increased as the number of CVC lumens increased (OR=2.24; 95% CI: 1.50–3.34, $p<0.001$ per unit increase). Males were less likely than females to develop a CAC, with an odds ratio of 0.62 (95% CI: 0.42–0.91, $p<0.05$).

Description of CLABSIs

The absolute number of CLABSIs identified in the study population was small at 16 or 2.4% of the total cohort. In the multivariable analysis for CLABSI as an outcome, TPN as an indication for CVC (OR=7.90; 95% CI: 1.00–62.46), male sex (OR=1.9, 95% CI: 0.63–5.17), neutropenia at the time of CVC insertion (OR=1.71, 95% CI: 0.24–12.28), and the number of CVC lumens (OR=1.68, 95% CI: 0.57–4.99) were not statistically significant. Younger age was the only factor significantly associated with an increased risk for the development a CLABSI, as patients 5 years of age had nearly 5 times the odds of CLABSI compared to patients of the median age (OR=4.80; 95% CI: 1.06–21.75 vs. 44 year-olds). There seemed to be a protective factor for CLABSIs (crude OR=0.57; 95% CI: 0.33–0.99, $p<0.05$) when the CVC was accessed more than once daily. Of the 16 CLABSIs, the most common organism isolated was Klebsiella spp. (in 5 events), followed by Candida sp. (4) (Table 3). There was also one CLABSI due to *Mycobacterium chelonae* in a patient receiving TPN.

Discussion

There was a substantial rate of CACs in patients who left the hospital with a CVC in place, with 1 in 5 patients requiring at least one medically attended visit because of the CVC or infusate. Fortunately, formal CLABSI events were rare. We did find certain groups were more likely to develop a CAC, such as those with CVCs with more than one lumen, females, and those receiving TPN as the infusate. We believe that further investigation is needed to determine modifiable risk factors in these groups.

The most common reason for a CAC was loss of patency, prohibiting infusion. Currently, many home health agency policies prohibit home health nursing agencies from carrying tPA in the patient's home due to concerns for accidental infusion by the patient; thus all tPA has to be administered in a clinic or ED. The second most common reason for a CAC was a mechanical complication which ranged from accidentaly breaking or removing the external parts of the CVC or pulling it out partially, and problems with the dressing that could not be remedied by the home health nurse. Etiology of many of these mechanical complications may be related to patient education or health literacy, the degree to which patients can obtain, process, and understand basic health information and services needed to make appropriate health decisions.[12] Further study into this potential association between health literacy and CACs in CVC patients is needed.

Female sex has been associated with a higher risk of catheter associated-urinary tract infections but not necessarily other healthcare associated infections.[13] This finding of increased risk of developing a CAC among female patients in the outpatient CVC population was surprising and without a clear pathophysiologic explanation. On the other hand, the finding of increased risk of CAC with multiple lumens is consistent with known literature. Multiple lumens carry an increased risk of CLABSI as well as other complications such as catheter associated thrombosis.[14,15]

An increased risk of CLABSI with TPN and chemotherapy has been noted previously, and we found increased odds of CLABSI among those receiving TPN (OR=9.81; 95% CI: 2.53–

38.04, p<0.001) and chemotherapy (crude OR=4.07; 95% CI: 1.07–15.45, p<0.05) when compared to OPAT.[16] This risk did not remain significant in the multivariable regression analysis when we adjusted for comorbidities, including current malignancy, chronic inflammatory bowel disease, receipt of any immunosuppressant, and neutropenia. A study examining a pediatric oncology cohort found that the absolute number of outpatient CLABSIs was about twice the number of inpatient CLABSIs in the same period of time.[17] Our cohort did not have similar findings, likely due to the lower number of patients with cancer. However, we did find that 7 of the 16 CLABSIs were in the pediatric population, suggesting this population could be prioritized for the development of innovative maintenance bundles.

The microbiology of the outpatient CLABSIs was remarkable in that 10 events were due to gram negative bacteria and 4 were due to Candida species. Of these 4 Candida bloodstream infections, all were associated with PICC lines, and 3 occurred in patients receiving OPAT. Broad spectrum antimicrobial exposure and CVCs are both major factors for candidemia.[18] According to a recent multistate point prevalence study, Candida species are the most common pathogens causing healthcare-associated bloodstream infections; however, 4 Candidal infections out of 16 total events is still higher than noted in previous studies.[19]

One of the most striking discoveries was the number of times the CVCs were accessed each day. Almost 44% of the patients were required to access the CVC two or more times a day, and 27.8% were required to access the line three or more times a day. Many inpatient CLABSI prevention bundles tend to include maintanence recommendations that minimize access of the catheter, as well as other attempts to minimize catheter hub microbial contamination.[20,21] Tomar et al, found that Pediatric ICU patients with a CLABSI had their CVC accessed an average of 18.46 vs 11.7 times a day in the cohort without a CLABSI.[22] Thus we hypothesized increased frequency of access/day would increase the risk of CLABSI or other complications, especially since the person accessing the CVC is typically not a trained healthcare professional nor as aware of standard infection prevention practices. However, when comparing the number of times the CVC was accessed daily (or frequency of access) there seemed to be a protective factor for CLABSIs (crude OR=0.57; 95% CI: 0.33–0.99, p<0.05) when the CVC was accessed more than once daily. A possible explanation for this finding could ultimately be in the reason for the multiple catheter accessions in the inpatient CVC vs. outpatient CVC. Typically, outpatients have their lines accessed for the sake of blood draws only once per week, and blood sampling from the CVC has been reported as a risk for the development of CLABSI.[23,24] It is also possible that those patients or caregivers administering infusions more frequently were more accustomed to good catheter hub cleaning technique. This study did not find a significant effect of frequency of line access on developing a CAC.

This study does have some potential limitations. It is a single center study and may be susceptible to local practices regarding patient education on CVC maintenance. Patient data were collected from VUMC records only, and thus there is a risk of missing a CLABSI or a CAC that required an inpatient admission elsewhere. We believe this risk was low because VCHS would have initiated a new admission into their care after an inpatient admission, and the redundant case records would have triggered a review by study personnel. There is also a

possibility that a CAC requiring an outpatient visit with a non-Vanderbilt provider would not be captured by the study methods; however, this is unlikely since the care for the CVC would have been ordered by a Vanderbilt provider at hospital discharge and thus complications would tend to be managed by that provider. Unfortunately, we were unable to collect data on total catheter days since the exact date of CVC discontinuation was not documented consistently. CVC duration is a known risk factor for CLABSI, and thus was a likely confounder when interpreting the risk analysis for outpatient CLABSI. Most healthcare systems do not routinely collect catheter days on outpatient CVCs, except for cohorts of stem cell patients, and thus we stress the need for improved formal surveillance mechanisms in outpatients with CVCs.

While CVCs are helpful and effective at allowing certain patients to leave the hospital and still receive their prescribed infusions, these CVCs are not without a substantial rate of complications. This study is one of the largest describing purely outpatient complications secondary to CVCs and the infusate. We found the most common complication was due to obstruction that either required tPA or replacement of a catheter. There are some institutional procedures that may be able to assist in preventing these unexpected encounters. Fortunately, outpatient CLABSIs were rare. Further study and formal surveillance of patients in the outpatient setting would help elucidate modifiable risk factors for CACs and CLABSIs.

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Appendix

The CPT codes used were 86.07 (insertion of totally implantable vascular access device), 86.06 (insertion of totally implantable infusion pump), 38.97 (central venous catheter placement with guidance), and 38.93 (venous catheterization).

Immune suppressant = steroid ≥ 20mg prednisone daily, biologic/monoclonal antibody, methotrexate, azathioprine, hydroxychloroquine, calcineurin inhibitor, M-TOR inhibitor, cyclosporin, mycophenolate.

Table 1

Characteristics of the population of patients and their CVCs.

	# Total (%)
AGE (Years)	654
<19	154
20–59	334
≥60	166
SEX	654
Female	305 (46.6%)
Male	349 (53.4%)
CVC INDICATION	653
OPAT	483 (74.0%)
Chemotherapy	98 (15.0%)
TPN	43 (6.6%)
Other	29 (4.4%)
CATHETER TYPE	651
PICC	533 (81.8%)
Subcutaneous Port	76 (11.6%)
Central Non-Tunnelled CVC	19 (2.9%)
Central Tunnelled CVC	23 (3.5%)
H/o stem cell transplant < 1 year[a]	6 (0.9%)
H/o solid organ transplant[a]	27 (4.0%)
Received chemotherapy[a]	109 (16.3%)
Neutropenia (ANC<500)[a]	31 (4.6%)
Inflammatory bowel disease[a]	98 (14.7%)
Use of ANY immunosuppressant[b*]	68 (10.2%)

[a] missing data for N=18 (2.7%),

[b] missing data for N=14 (2.1%).

[*] steroid ≥ 20mg predinsone, biologic/monoclonal antibody, methotrexate, azathioprine, hydroxychloroquine, calcineurin inhibitor, mTOR inhibitor, cyclosporin, mycophenolate

Abbreviations: CVC=central venous catheter, OPAT=Outpatient parenteral antimicrobial therapy, TPN=total parenteral nutrition, PICC=peripherally inserted central catheter, ANC=absolute neutrophil count.

Table 2

Description of CACs with number and percentage of total.

Description of CACs	# (% CACs)
Loss of patency	60 (36.4%)
Other mechanical complication	43 (26.1%)
Suspected Infection, CLABSI ruled out	38 (23.0%)
CLABSI	16 (9.7%)
Toxicity related to infusate	6 (3.6%)
Thrombotic event	2 (1.2%)
Total CACs	**165**

Loss of patency was defined as inability to infuse. Mechanical complications included catheter pulled out partially or wholly, broken external parts, problem with the dressing, and one case of a broken olecranon after tripping over tubing of catheter. Suspected Infection, CLABSI ruled out was defined as patient presented with signs or symptoms concerning for sepsis but blood cultures were negative. Toxicity to infusate includes renal injury, severe nausea/vomiting, diarrhea, drug eruption or other hypersensitivity. Thrombotic event determined by ultrasound as venous thrombosis related to the catheter.

Abbreviations: CAC=medically attended catheter associated complication, CLABSI=central line associated bloodstream infection

Table 3

List of organisms causing outpatient CLABSIs.

Organism	# of isolates	% of total
Klebsiella spp	5	21.7%
Candida spp	4	17.4%
Staphylococcus aureus	3	13.0%
MRSA[a]	2	8.7%
MSSA[b]	1	4.4%
Enterococcus spp	3	13.0%
E. faecalis	2	8.7%
E. faecium	1	4.4%
Coag-Neg Staph[c]	2	8.7%
Escherichia coli	2	8.7%
Serratia spp	2	8.7%
Enterobacter spp	1	4.4%
Mycobacterium chelonae	1	4.4%
Grand Total	**23**[*]	**100.00%**

[a]Methicillin resistant *Staphylococcus aureus*

[b]Methicillin sensitive *Staphylococcus aureus*

[c]Coagulase negative Staphylococcus species

[*]6 of the CLABSIs were polymicrobial and one of these polymicrobial infections grew 3 different pathogens

Abbreviations: CLABSI=central line associated bloodstream infection