Title

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ORIGINAL RESEARCH

Comparison of Hospital Length of Stay, Costs, and Readmissions of Alteplase Versus Catheter Replacement Among Patients With Occluded Central Venous Catheters

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BACKGROUND: Central venous catheter (CVC) occlusion is common, affecting 30% of all CVCs.

OBJECTIVE: To compare length of stay (LOS), costs, and readmissions associated with the use of alteplase to clear catheter blockage to outcomes associated with catheter replacement.

DESIGN: Retrospective observational study utilizing a large hospital database.

PARTICIPANTS: Hospitalized patients treated for catheter occlusion from January 2006 to December 2011.

MAIN MEASURES: Univariate analyses of patient characteristics and treatment patterns and multivariable regression analyses of postocclusion hospital costs, LOS, and 30- and 90-day readmissions were conducted.

KEY RESULTS: We included 34,579 patients treated for a CVC occlusion by replacement (N = 1028) or by alteplase (2 mg) administration (N = 33,551). Patients receiving alteplase were somewhat younger than those having catheter replacement (60 ± 19 vs 62 ± 20 years old, $P = 0.0002$). After adjusting for patient and hospital factors via regression modeling, average daily postocclusion costs were $317 lower for alteplase recipients than for catheter replacement patients (95% confidence interval [CI]: 238.22–392.24; $P < 0.0001$). Adjusted total postocclusion costs were $1419 lower for alteplase recipients versus patients receiving catheter replacement (95% CI: 307.27–2458.12; $P = 0.0121$). Postocclusion operating room/surgery, radiology, and supply costs were significantly lower for alteplase recipients ($P < 0.001$). Average adjusted postocclusion LOS was similar for both groups ($P > 0.05$). Odds of readmission were not significantly different at 30 or 90 days.

CONCLUSIONS: Among patients treated for an occluded CVC, alteplase-treated patients had lower daily and total postocclusion costs than patients receiving catheter replacement. Cost differences were mainly driven by lower operating room/surgery, radiology, and supplier costs. *Journal of Hospital Medicine* 2014;9:490–496. © 2014 The Authors Journal of Hospital Medicine published by Wiley Periodicals, Inc. on behalf of Society of Hospital Medicine

Long-term central venous catheters (CVCs) facilitate care for patients with chronic illness by providing easy venous access for laboratory tests, administration of medication, and parenteral nutrition. However, several complications resulting from the use of CVCs, including sepsis, extravasation of infusions, and venous thrombosis, can increase associated morbidity and mortality. These complications can also interrupt and delay treatment for the underlying disease and thereby affect outcomes. One of the most common CVC complications is catheter occlusion.[1]

Catheter occlusion occurs in 14% to 36% of patients within 1 to 2 years of catheter placement.[2–8] A catheter occlusion can be partial or complete, and can occur secondary to a variety of mechanical problems, including an uncommon, but potentially life-threatening, pinch-off syndrome. Medication or parenteral nutrition can also cause occlusion, which can be acute or gradual, with increasingly sluggish flow through the catheter. Inappropriate concentrations or incompatible mixtures can cause medications to precipitate within the catheter lumen.

Occlusions are either thrombotic or nonthrombotic. One autopsy study of patients with a long-term CVC found that a fibrin sheath encased the catheter tip in every case.[9] An occluded catheter may compromise patient care[10,11]; it may cause cancellation or delay of procedures, it potentially interrupts administration of critical therapies including vesicants, it may result in risk of infection, and it potentially leads to catheter replacement. This can further complicate care, leading to increased length of stay (LOS) and hospital costs.

To better understand resource utilization, LOS, and cost implications of alteplase compared with catheter

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replacement, we conducted a preplanned, retrospective analysis of hospitalized patients captured between January 2006 and December 2011 in the database maintained by Premier. The Premier database is a large, US hospital-based, service-level, all-payer, comparative database, with information collected primarily from nearly 600 geographically diverse, nonprofit, nongovernment community and teaching hospitals.

METHODS

Data Sources

The Premier database contains information on over 42 million hospital discharges (mean 5.5 million discharges/year)—one-fifth of all US hospitalizations—from the year 2000 to the present. The database contains data from standard hospital discharge files, including patient demographic information and disease state. Patients can be tracked, with a unique identifier, across the inpatient and hospital-based outpatient settings, as well as across visits. In addition to the data elements available in most of the standard hospital discharge files, the Premier database also contains a date-stamped log of billed items, including procedures, medications, and laboratory, diagnostic, and therapeutic services at the individual patient level. Drug utilization information is available by day of stay and includes quantity, dosing, strength used, and cost.

The Premier database has been used extensively to benchmark hospital clinical and financial performance as well as by the US Food and Drug Administration (FDA) for drug surveillance and by the Centers for Medicare and Medicaid Services to evaluate next-generation payment models. Preliminary comparisons between patient and hospital characteristics for hospitals that submit data to Premier and those of the probability sample of hospitals and patients selected for the National Hospital Discharge Survey suggest that the patient populations are similar with regard to patient age, gender, LOS, mortality, primary discharge diagnosis, and primary procedure groups.

Patient Population

In this retrospective observational database analysis, inpatients of all ages were initially identified who were discharged from a hospital between January 1, 2006 and December 31, 2011 and whose records contained 1 or more International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9) procedural codes or Current Procedural Terminology (CPT-4) codes signifying CVC placement. The catheter replacement group comprised patients having a catheter replacement during the hospitalization. The alteplase treatment group was identified through patient billing records and by computing the dose administered (2 mg) during the index hospitalization period. Healthcare Common Procedure Coding System J-codes (J2996, alteplase recombinant injection 10 mg; J2997, alteplase recombinant 1 mg) were also evaluated during the analysis to supplement the search string identification. To account for and eliminate catheter replacement due to mechanical failure rather than occlusion, patients with ICD-9 diagnosis code 996.1 for mechanical failure were excluded. Patients with an ICD-9 diagnosis code for infection or who received antibiotics on the day of replacement were excluded as an additional way to narrow the study to patients with occlusion as the reason for catheter replacement. In addition, patients receiving kidney dialysis, a chronic condition prone to greater-than-usual risk of catheter occlusion, were excluded. When a patient had multiple hospital stays with CVC insertions or placement during the study period, the first hospitalization with insertions or placement was used in our analyses.

Of the CVC patient population (N = 574,252), 36,680 patient discharges resulted in the need for CVC replacement, alteplase therapy, or both. Patients receiving both replacement and alteplase (N = 144) were excluded from analysis, resulting in 33,551 patient discharges with alteplase and 1028 patient discharges with CVC replacement.

Outcome Measures

The main outcomes of interest were LOS and hospital costs after occlusion, and readmissions at 30 and 90 days. Secondary measures, as they were thought to play a role in influencing outcomes, included LOS and costs before occlusion, as well as departmental costs such as pharmacy, radiology, and days in the intensive care unit (ICU).

Statistical Analysis

Univariate descriptive statistics were used to characterize the patient population by patient, clinical, and hospital attributes. In addition, subgroup analyses were performed among patients with any cardiology diagnosis (using ICD-9 diagnosis or procedure codes), heart failure, myocardial infarction, and cancer, which were potentially overlapping categories chosen prior to initiating the analyses. Data measured on a continuous scale were expressed as mean, standard deviation, range, and median. Categorical data were expressed as count/percentages in the categories. In addition, categorical costs were also examined before and after occlusion. Tables of results included *P* values comparing patients who received CVC replacement with those who received alteplase across all measures. The χ^2 tests were used to test for differences in categorical variables, and *t* tests were utilized for differences in continuous variables.

Multivariable regression modeling was conducted to better compare outcomes associated with catheter replacement versus alteplase treatment. Linear regression models were performed to evaluate hospital costs and LOS during the initial hospital discharge. Logistic regression models were performed to evaluate the odds of readmission at 30 and 90 days following discharge. All multivariable models controlled for factors found to be statistically significant in univariate analysis. The covariates varied by model, but generally included age, race, sex, cancer, 3M All Patient Refined Diagnosis Related Group risk of mortality and severity of illness, cerebrovascular disease, renal disease, payer, myocardial infarction, hemiplegia/paraplegia, chronic or acute diabetes, peripheral vascular disease, complication, admission source, admission type, congestive heart failure, dementia, metastatic solid tumor, rheumatic disease, peptic ulcer disease, chronic pulmonary disease, hospital teaching status, urban/rural location, US Census region, and number of hospital beds. Certain of these variables, such as 3M measures of severity and risk, as well as measures of LOS and costs before occlusion, were considered as ways to understand differences in risk of increased costs among patients. For each multivariable model, covariates eligible for inclusion in the models were selected using a backward selection method (logistic used stepwise) until all variables remaining in the model were significant at $P \leq 0.2$.

RESULTS

This study included 34,579 patients who first had a CVC insertion and then were treated for a CVC occlusion by receiving a replacement CVC (n = 1028) or by receiving alteplase (2 mg) administration (n = 33,551) during the same hospitalization (Table 1). Patients who received alteplase tended to be younger (60 ± 19 vs 62 ± 20 years old). More than 50% were at least 65 years of age. Twelve percent of alteplase patients were black, whereas 18.5% of catheter-replacement patients were black.

Alteplase patients were significantly more likely to have a diagnosis of chronic pulmonary disease, liver disease, renal disease, chronic diabetes (ie, diabetes with complications), and cancer. There was an equivalent number of urban and rural hospitals across the 2 groups of patients (Table 2); however, there were regional differences including a higher proportion of catheter-replacement patients from the East North Central and Middle Atlantic areas and a lower proportion of catheter-replacement patients from Mountain and Pacific states. Catheter-replacement patients more frequently were treated in teaching hospitals and in hospitals of larger size.

After covariate adjustment for baseline measurements significantly related to each outcome, average daily post occlusion costs were estimated to be $317 lower for alteplase recipients than for patients who received catheter replacement ($317; 95% confidence interval [CI]: $238-$392; $P < 0.0001$) (Table 3). Average adjusted total post occlusion costs were $1419 lower for alteplase recipients than for patients who received catheter replacement ($1418; 95% CI: $307-$2458; $P = 0.012$).

TABLE 1. Baseline Patient Characteristics

	Catheter Replacement, n = 1,028	Alteplase Treatment, n = 33,551
Age group, y*		
Under 18	29 (2.8%)	984 (2.9%)
18–34	84 (8.2%)	2,479 (7.4%)
35–44	73 (7.1%)	2,826 (8.4%)
45–54	116 (11.3%)	5,217 (15.5%)
55–64	210 (20.4%)	6,761 (20.1%)
65–74	203 (19.7%)	6,741 (20.1%)
75+	313 (30.4%)	8,543 (25.5%)
Mean (SD)	62 (20)	60 (19)
Sex		
Female	565 (55.0%)	18,172 (54.2%)
Male	463 (45.0%)	15,378 (45.8%)
Unknown	0 (0%)	1 (0%)
Race/ethnicity*		
Black	190 (18.5%)	4,057 (12.1%)
Hispanic	40 (3.9%)	1,098 (3.3%)
Other	126 (12.3%)	6,250 (18.6%)
White	672 (65.4%)	22,146 (66.0%)
Comorbid conditions		
Myocardial infarction	96 (9.3%)	3,746 (11.2%)
Congestive heart failure	258 (25.1%)	8,210 (24.5%)
Peripheral vascular disease	104 (10.1%)	3,451 (10.3%)
Cerebrovascular disease	115 (11.2%)	3,528 (10.5%)
Dementia	33 (3.2%)	838 (2.5%)
Chronic pulmonary disease*	264 (25.7%)	10,495 (31.3%)
Rheumatic disease	37 (3.6%)	1,344 (4.0%)
Peptic ulcer disease	41 (4.0%)	1,068 (3.2%)
Mild liver disease*	94 (9.1%)	2,392 (7.1%)
Moderate/severe liver disease*	29 (2.8%)	531 (1.6%)
Acute diabetes	255 (24.8%)	9,185 (27.4%)
Chronic diabetes*	44 (4.3%)	2,327 (6.9%)
Hemiplegia paraplegia	51 (5.0%)	1,909 (5.7%)
Renal disease*	209 (20.3%)	5,351 (16.0%)
Cancer*	207 (20.1%)	5,685 (16.9%)
Metastatic solid tumor*	100 (9.7%)	2,441 (7.3%)
AIDS/HIV	4 (0.4%)	244 (0.7%)
3M™ APR™-DRG Severity of Illness*		
1-minor	36 (3.5%)	769 (2.3%)
2-moderate	172 (16.7%)	4,109 (12.2%)
3-major	384 (37.3%)	12,175 (36.3%)
4-extreme	436 (42.4%)	16,497 (49.2%)
Unknown	0 (0%)	1 (0%)
3M APR-DRG Risk of Mortality*		
1-minor	159 (15.5%)	4,716 (14.1%)
2-moderate	253 (24.6%)	6,746 (20.1%)
3-major	313 (30.4%)	10,569 (31.5%)
4-mxtreme	303 (29.5%)	11,519 (34.3%)
Unknown	0 (0%)	1 (0%)

NOTE: **Abbreviations:** AIDS, acquired immune deficiency syndrome; APR-DRG, All Patient Refined Diagnosis Related Group; HIV, human immunodeficiency virus; SD, standard deviation.

*χ^2 test, 2-sided, $P < 0.05$.

Contributing to the lower cost were certain revenue-center specific costs (Table 4). Total room and board costs were different between the alteplase and catheter-replacement groups in both the pre- and postocclusion periods; this was related to the difference between the 2 comparison groups in postocclusion LOS of about 0.3 days (Table 5). However, the differences favored alteplase use over catheter replacement. Cardiology/electrocardiography costs were

TABLE 2. Baseline Hospital and Discharge Characteristics

	Catheter Replacement, n = 1,028	Alteplase Treatment, n = 33,551
Provider region*		
New England	28 (2.7%)	976 (2.9%)
Middle Atlantic	227 (22.1%)	1,944 (5.8%)
South Atlantic	247 (24.0%)	8,047 (24.0%)
East North Central	153 (14.9%)	3,015 (9.0%)
East South Central	14 (1.4%)	1,345 (4.0%)
West North Central	98 (9.5%)	3,590 (10.7%)
West South Central	112 (10.9%)	5,096 (15.2%)
Mountain	48 (4.7%)	3,339 (9.9%)
Pacific	94 (9.1%)	6,083 (18.1%)
Unknown	7 (0.7%)	116 (0.3%)
Population served		
Rural	56 (5.4%)	1,838 (5.5%)
Urban	972 (94.6%)	31,713 (94.5%)
Teaching status*		
Nonteaching	431 (41.9%)	18,598 (55.4%)
Teaching	597 (58.1%)	14,953 (4.6%)
Hospital size, no. of beds*		
<100	4 (0.4%)	475 (1.4%)
100–199	56 (5.4%)	1,725 (5.1%)
200–299	124 (12.1%)	5,907 (17.6%)
300–499	432 (42.0%)	13,790 (41.1%)
500+	412 (40.1%)	11,654 (34.7%)
Primary payor*		
Commercial	50 (4.9%)	1,779 (5.3%)
Managed care	221 (21.5%)	6,888 (20.5%)
Medicaid	132 (12.8%)	4,146 (12.4%)
Medicare	572 (55.6%)	17,226 (51.3%)
Other government programs	9 (0.9%)	439 (1.3%)
Any other payor	44 (4.3%)	3,073 (9.2%)
Admission source*		
Emergency department	424 (41.2%)	12,741 (38.0%)
Physician referral	390 (37.9%)	14,502 (43.2%)
Transfer from another health facility	154 (15.0%)	4,109 (12.2%)
Unknown	60 (5.8%)	2,199 (6.5%)
Admission type*		
Elective	205 (19.9%)	5,872 (17.5%)
Emergency	613 (59.6%)	19,660 (58.6%)
Newborn	9 (0.9%)	37 (0.1%)
Trauma center	3 (0.3%)	279 (0.8%)
Urgent	192 (18.7%)	7,573 (22.6%)
Unknown	6 (0.6%)	130 (0.4%)

*NOTE: χ^2 test, 2-sided, $P < 0.05$.

lower for catheter replacement in the preocclusion period but lower for alteplase use in the postocclusion period. Emergency department costs were higher for catheter replacement in both periods, as were respiratory costs in the same manner. Additionally, costs for laboratory tests, nursing, operating room/surgery, pharmacy, radiology, supplies, and ICU room and board were lower in the preocclusion period but higher in the postocclusion period for catheter-replacement patients. It was unclear why the pharmacy costs after catheter replacement would have increased for catheter-replacement patients in contrast to the decrease for alteplase-treated patients, but because this occurred at an average daily basis as well, it appeared that catheter-replacement patients may have received additional medications. Average adjusted postocclusion LOS was similar for alteplase and catheter-replacement recipients ($P = 0.24$), suggesting that decreased total costs were due to reasons other than shorter LOS.

TABLE 3. Unadjusted Summary of Readmissions, Total Hospital Costs, and Length of Stay

	CVC Replace Only, n = 1,028	Alteplase Only, n = 33,551
30-day readmission	24.6%	23.7%
90-day readmission	35.1%	33.9%
Preocclusion		
Mean (SD) length of stay, days	3.8 (6.7)	7.3 (6.9)
Mean (SD) total cost	$10,485 ($29,088)	$18,546 ($22,658)
Mean (SD) cost per day	$2,876 ($3,046)	$2,637 ($1,783)
Postocclusion		
Mean (SD) length of stay, days	8.8 (11.0)	8.8 (10.0)
Mean (SD) total cost	$18,714 ($32,189)	$16,765 ($29,966)
Mean (SD) cost per day	$2,146 ($2,995)	$2,058 ($6,585)

NOTE: **Abbreviations:** CVC, central venous catheter; SD, standard deviation.

Unadjusted 30- and 90-day readmission rates were 24.6% and 35.1% for CVC replacement and slightly lower at 23.7% and 33.9% for alteplase (Table 3), respectively. Odds of readmission after adjusting for patient and hospital factors were not significantly different at 30 days (odds ratio [OR]: 1.048, 95% CI: 0.899-1.221; $P = 0.55$) or at 90 days (OR: 1.051, 95% CI: 0.915-1.207; $P = 0.48$) (Table 5). Subgroup analyses for patients with a diagnosis of heart failure, myocardial infarction, and cancer revealed similar results.

DISCUSSION

The cost of healthcare in the United States has risen at an outstanding rate compared with other countries. Our percentage of gross national product spent on healthcare is on the order of 16% to 18%, almost twice as much as the next most industrialized country in terms of healthcare expenditure.[12] In the current era, finding opportunities to reduce healthcare costs without negatively impacting quality of care is the name of the game. Professional societies have come together under the campaign of Choosing Wisely: An Initiative of the ABIM (American Board of Internal Medicine) Foundation to help educate clinicians and patients on cost-containment strategies.[13] Research that demonstrates opportunities to reduce cost will help healthcare providers "choose wisely" among diagnostic and therapeutic options for patients. Our study demonstrated that the use of a drug such as alteplase in clearing CVC catheter obstruction was significantly less costly to the hospital than catheter replacement.

Cathflo Activase (alteplase: Genentech, South San Francisco, CA), the only FDA-approved thrombolytic for the restoration of central venous catheter function, is the current standard treatment for catheter

TABLE 4. Unadjusted Pre- and Postocclusion Departmental Costs

	Preocclusion*		Postocclusion*	
	CVC Replacement Only, n = 1,028	Alteplase Only, n = 33,551	CVC Replacement Only, n = 1,028	Alteplase Onlyn = 33,551
Total room and board cost				
Mean (SD) total cost	$4,380 ($9,545)	$8,535 ($10,175)†	$8,394 ($14,393)	$8,437 ($18,341)†
Mean (SD) cost per day	$693 ($734)	$1,097 ($724)†	$751 ($536)	$983 ($3,250)
Cardiology/ECG cost				
Mean (SD) total cost	$82 ($806)	$154 ($605)†	$124 ($540)	$107 ($735)†
Mean (SD) cost per day	$17 ($96)	$26 ($131)†	$17 ($93)	$19 ($217)†
Emergency department cost				
Mean (SD) total cost	$10 ($91)	$36 ($284)†	$10 ($67)	$12 ($195)
Mean (SD) cost per day	$4 ($32)	$8 ($65)†	$2 ($19)	$6 ($76)
Laboratory cost				
Mean (SD) total cost	$864 ($2,538)	$1,425 ($3,622)†	$1,471 ($5,614)	$1,175 ($3,961)
Mean (SD) cost per day	$140 ($314)	$180 ($269)†	$139 ($313)	$142 ($465)†
Nursing Cost				
Mean (SD) total cost	$218 ($1,497)	$224 ($2,364)†	$432 ($2,538)	$231 ($2,785)
Mean (SD) cost per day	$39 ($166)	$24 ($127)†	$35 ($140)	$21 ($112)
OR/surgery cost				
Mean (SD) total cost	$902 ($4,743)	$1,602 ($3,597)†	$1,437 ($3,029)	$847 ($2,701)†
Mean (SD) cost per day	$207 ($495)	$267 ($513)†	$302 ($646)	$130 ($827)†
Pharmacy cost				
Mean (SD) total cost	$2,085 ($20,338)	$3,014 ($6,408)†	$3,200 ($16,396)	$2,914 ($8,383)†
Mean (SD) cost per day	$263 ($1,509)	$368 ($583)†	$362 ($2,427)	$347 ($853)†
Radiology cost				
Mean (SD) total cost	$470 ($869)	$782 ($1,031)†	$731 ($1,160)	$505 ($1,550)†
Mean (SD) cost per day	$133 ($362)	$130 ($189)†	$144 ($293)	$83 ($469)†
Respiratory cost				
Mean (SD) total cost	$391 ($1,442)	$895 ($2,160)†	$673 ($2,209)	$783 ($2,297)†
Mean (SD) cost per day	$51 ($121)	$104 ($170)†	$61 ($115)	$81 ($280)†
Supply cost				
Mean (SD) total cost	$834 ($3,221)	$1,408 ($5,871)†	$1,636 ($7,250)	$1,117 ($4,477)†
Mean (SD) cost per day	$208 ($1,244)	$211 ($789)†	$264 ($871)	$165 ($1,529)†
Other therapy cost				
Mean (SD) total cost	$179 ($702)	$355 ($815)†	$436 ($837)	$509 ($1,263)†
Mean (SD) cost per day	$30 ($81)	$46 ($98)†	$51 ($106)	$66 ($481)†
Other departments cost				
Mean (SD) total cost	$26 ($710)	$1 ($36)	$74 ($1,127)	$3 ($144) †
Mean (SD) cost per day	$3 ($56)	$0 ($5)	$6 ($86)	$0 ($13)†
Fees cost				
Mean (SD) total cost	$38 ($370)	$82 ($969)†	$67 ($340)	$86 ($2,704)
Mean (SD) cost per day	$7 ($47)	$12 ($77)†	$12 ($120)	$12 ($843)
Healthcare services cost				
Mean (SD) total cost	$5 ($53)	$31 ($1,052)†	$29 ($515)	$35 ($1,162)
Mean (SD) cost per day	$1 ($10)	$3 ($65)†	$2 ($11)	$3 ($54)
ICU room and board cost				
Mean (SD) total cost	$2,085 ($7,700)	$4,333 ($8,826)†	$3,158 ($10,767)	$2,884 ($15,863)
Mean (SD) cost per day	$293 ($677)	$543 ($854)†	$222 ($512)	$323 ($2,330)

NOTE: **Abbreviations:** CVC, central venous catheter; ECG, electrocardiograph; ICU, intensive care unit; SD, standard deviation.

*Differences tested using nonparametric Wilcoxon ranked sum (Mann-Whitney *U*) test, 2-sided $\alpha = 0.05$.

†$P < 0.05$.

occlusions in the United States. A dose of 2 mg in 2 mL is instilled in patients weighing ≥30 kg or 110% of the internal lumen volume of the catheter not to exceed 2 mg in 2 mL for those patients weighing <30 kg. Haire et al. showed that a 2-mg dose of alteplase was more effective than urokinase (5000 IU) for treating radiographically proven thrombotic occlusion of a CVC after a dwell time of 120 minutes.[14] In the Cardiovascular thrombolytic used to Open Occluded Lines (COOL) trial, one 2-mg dose of alteplase cleared the catheter occlusion after 120 minutes in 74% of patients, compared with only 17% of patients who received a placebo. Studies have confirmed the safety and efficacy of alteplase administered at various time intervals in different long-term catheters, including peripherally inserted central catheters, with major hemorrhage reported in 0.3% of patients.[15–17]

Adding to the knowledge of patient outcomes from clinical studies, many health outcomes studies have demonstrated benefit in cost containment through decreasing LOS, which one can argue is just shifting the cost to an earlier part of the stay. Even though

TABLE 5. Multivariable Regression Models Comparing Alteplase Treatment to Catheter Replacement

Model	Parameter Estimate	Summary Statistic	Estimate (95% CI)
30-day readmission*	0.0234	Odds ratio	1.048 (0.899 to 1.221)
90-day readmission†	0.0248	Odds ratio	1.051 (0.915 to 1.207)
Postocclusion total costs‡	−0.0842	Mean difference§	−$1,418.69 (−$2,458.12 to −$307.27)‖
Postocclusion total cost per day**	−0.1857	Mean difference§	−$317.20 (−$392.24 to −$238.22)‖
Post occlusion length of stay††	0.0313	Mean difference§	0.299 (−0.196 to 0.820)

NOTE: **Abbreviations:** APR-DRG, All Patient Refined Diagnosis Related Group; CI, confidence interval.

*Model adjusts for: cancer, region, 3M APR-DRG Risk of Mortality, teaching hospital, cerebrovascular disease, race, renal disease, payor, myocardial infarction, gender, hemiplegia/paraplegia.

†Model adjusts for: cancer, region, 3M-APR DRG Risk of Mortality, payor, chronic diabetes, sex, myocardial infarction, teaching hospital, race, peripheral vascular disease, hemiplegia/paraplegia, renal disease.

‡Model adjusts for: age, sex, race, region, 3M APR-DRG Risk of Mortality, complication, teaching hospital, bed size, admission source, admission type, 3M APR-DRG Severity of Illness, congestive heart failure, cerebrovascular disease, dementia, chronic diabetes, hemiplegia/paraplegia, renal disease, cancer, metastatic solid tumor.

§Mean difference computed as value for alteplase treatment minus value for catheter replacement.

**Model adjusts for: age, race, region, urban/rural, 3M APR-DRG Risk of Mortality, complication, teaching hospital, bed size, payor, admission source, admission type, 3M APR-DRG Severity of Illness, congestive heart failure, peripheral vascular disease, dementia, rheumatic disease, peptic ulcer disease, acute diabetes, chronic diabetes, renal disease, cancer.

‖$P < 0.05$.

††Model adjusts for: age, sex, race, region, 3M APR-DRG Risk of Mortality, complication, teaching hospital, bed size, payor, admission type, 3M APR-DRG Severity of Illness, peptic ulcer disease, chronic pulmonary disease, chronic diabetes, hemiplegia/paraplegia, metastatic solid tumor, cancer, myocardial infarction.

this is highly beneficial, it does not address the core resource utilization within the hospital. Our study found its cost benefit not in the LOS, but in decreasing core resource utilization such as radiology, lab, nursing, and supplies. If patients are admitted for a noncardiovascular condition and have CVC occlusion, using alteplase to clear the CVC occlusion along with implementing strategies to manage the underlying disease to reduce the LOS becomes a powerful opportunity to impact cost. Among patients who may come to the hospital for just the CVC occlusion, the LOS should be short. There may be no significant opportunity to reduce the LOS in those cases, but opportunities to decrease core hospital resource utilization with alteplase make this approach beneficial if the patient can tolerate it.

Limitations of the study include the retrospective and administrative nature of the database used, which is unable to provide certain clinical measures as would be available at the patient's bedside when treatment choices are being made. Had they been available, we might have included them in our assessment of whether patients who underwent CVC replacement were significantly different from those who received alteplase. In addition, not all hospitals in the database had charge masters that facilitated identification of CVC replacements or reinsertions, requiring the use of CPT-4 codes and evidence of new CVCs being placed or inserted. Certain patients were excluded if there was conflicting information about whether the CVC was new within the hospital stay or dwelling in the patient prior to admission. Also, dialysis patients were excluded because they were not part of any approved indication for alteplase 2 mg, and this group is particularly prone to catheter obstruction. As such, they represent more complicated cases than the norm; this exclusion may have limited the overall generalizability of the study. The study also relied on charge master (billing) data to identify the use of alteplase and other treatments, where there is the potential, albeit minimal, for inaccuracies in the data. Of greater importance, the study relied on ICD-9 coding to identify comorbid conditions, and as in other studies using similar data sources, such methods are subject to coding errors and omissions. However, many of the listed limitations above were not thought to be different between the comparison groups or more problematic for this study than for other studies based on similar data sources.

CONCLUSION

Among patients treated for an occluded CVC, alteplase-treated patients had lower daily postocclusion costs and lower total postocclusion costs than patients who received catheter replacement. Differences in costs did not appear to be driven by differences in postocclusion LOS. Readmissions at 30- and 90-day periods were found to be similar between alteplase recipients and catheter-replacement patients.

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