Economic Burden to Dialysis Providers of Central Venous Catheter-Related Blood Stream Infections and Occlusions among Incident Hemodialysis Patients

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Introduction

- Vascular access type used for hemodialysis (HD) has profound consequences for patient outcomes.
  - Central venous catheter (CVC) use is associated with greater morbidity, mortality, and healthcare utilization compared to other access types.[1,2]
- CVC use adversely impacts clinical outcomes as a consequence of complications such as blood stream infections (BSI) and catheter occlusions.[3,4]
- Both BSI and CVC occlusions may have economic consequences for dialysis providers:
  - BSIs may result in missed dialysis treatments due to hospitalizations, increased use of antibiotics, and accompanying inflammation may also lead to greater erythropoiesis-stimulating agent and intravenous (IV) iron requirements.
  - CVC occlusions may require the use of thrombolytics and may also result in missed dialysis treatments.

Objective

To quantify the clinical and economic burden of CVC-related BSI and occlusions borne by dialysis providers under current reimbursement.

Methods

- The source cohort of patients were adult, non-veteran patients who initiated in-center HD via a CVC at a large dialysis organization (LDO) between January 2013 and March 2014.
- In parallel analyses, patients who developed BSI (N = 3269) or catheter occlusion (N = 676) during the first 180 days of HD treatment were matched to control CVC-HD patients who did not develop BSI or occlusion during this period.
  - BSI was defined based on LDO infection surveillance data.
- Missed HD treatment rates and medication utilization were considered from the date of BSI/occlusion (or corresponding date in matched BSI/occlusion patient for controls) for 180 days or until censoring for death, modality change, or loss to follow-up.
- Costs were derived using payor-specific remuneration rates for missed treatments, LDO acquisition costs for IV iron and ESA, and average wholesale prices for antibiotics and thrombolytics.
- Differences between BSI/occlusion patients and respective controls were estimated using linear mixed models including fixed effects for exposure status and month.
  - Adjusted models also included covariate terms for patient characteristics that were imbalanced at baseline.

Results

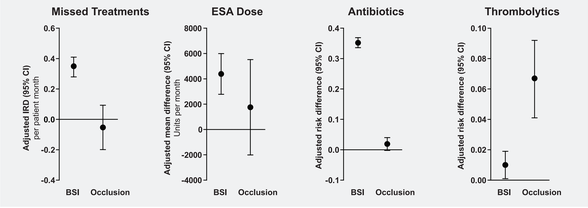
- Baseline characteristics of BSI/CVC occlusion patients and controls are shown in Table 1.
- After adjustment for baseline differences, BSI was associated with 0.35 more (95% CI: 0.28, 0.41) missed treatments per patient month, an increase in ESA dose of 4,389 (95% CI: 2,781, 5,997) units per month, and a 35.2% (95% CI: 0.336, 0.369) increase in patients treated with IV antibiotic (Figure 1).
- After adjustment for baseline differences, CVC occlusion was associated with a 6.7% (95% CI: 0.041, 0.092) increase in monthly thrombolytic use (Figure 1).
- Adjusted costs were $397 greater (95% CI: $355, $440) per month for each of the 6 months following BSI and no different following CVC occlusion (Figure 2).

Table 1: Demographic and Baseline Characteristics of CVC Patients with or without BSI and CVC Patients with or without Occlusion

		CVC without BSI N = 1413	CVC with BSI N = 1413	*P*-Value	CVC without Occlusion N = 793	CVC with Occlusion N = 793	*P*-Value
Age, years	mean ± SD	62.6 ± 15	58.9 ± 15.6	< 0.001	62.0 ± 14.5	60.9 ± 14.5	0.19
Race/Ethnicity	n (%)			0.13			0.02
White		1454 (44.5)	1419 (43.4)		311 (46.0)	279 (41.3)	
Black		965 (29.5)	1049 (32.1)		192 (28.4)	242 (35.8)	
Hispanic		570 (17.4)	528 (16.2)		118 (17.5)	114 (16.9)	
Other/Unknown/Missing		280 (8.6)	273 (8.4)		55 (8.1)	41 (6.1)	
Sex	n (%)			0.23			0.10
Female		1435 (43.9)	1483 (45.4)		312 (46.2)	342 (50.6)	
Payor	n (%)			< 0.001			0.14
Medicare		2015 (61.6)	1839 (56.3)		417 (61.7)	433 (64.1)	
Medicaid		474 (14.5)	638 (19.5)		116 (17.2)	132 (19.5)	
Commercial		641 (19.6)	625 (19.1)		121 (17.9)	95 (14.1)	
Other		139 (4.3)	167 (5.1)		22 (3.3)	16 (2.4)	
Etiology of ESRD	n (%)			0.17			0.93
Diabetes		1401 (42.9)	1472 (45.0)		307 (45.4)	313 (46.3)	
Hypertension		991 (30.3)	934 (28.6)		205 (30.3)	199 (29.4)	
Other/Unknown/Missing		877 (26.8)	863 (26.4)		164 (24.3)	164 (24.3)	
Diabetes	n (%)	2144 (65.6)	2136 (65.3)	0.84	437 (64.6)	431 (63.8)	0.73
Congestive heart failure	n (%)	658 (20.1)	637 (19.5)	0.52	140 (20.7)	126 (18.6)	0.34
Coronary artery disease	n (%)	90 (2.8)	69 (2.1)	0.09	22 (3.3)	15 (2.2)	0.24
Cerebrovascular disease	n (%)	51 (1.6)	28 (0.9)	0.009	8 (1.2)	8 (1.2)	> 0.9
Peripheral vascular disease	n (%)	203 (6.2)	164 (5.0)	0.04	35 (5.2)	33 (4.9)	0.80
Body weight, kg							
	mean ± SD	81.5 ± 24.0	84.8 ± 25.4	< 0.001	81.8 ± 23.2	82.4 ± 24.6	0.68
	median [p25, p75]	77.1 [64.7, 93.9]	80.4 [67.2, 98.3]		77.5 [61.5, 94.5]	77.8 [64.8, 96.5]	
nPCR, g/kg/day							
	mean ± SD	0.72 ± 0.33	0.68 ± 0.32	< 0.001	0.78 ± 0.36	0.76 ± 0.34	0.19
	median [p25, p75]	0.67 [0.43, .93]	0.63 [0.42, 0.88]		0.75 [0.50, 1.00]	0.72 [0.51, 0.95]	
Serum albumin, g/dL							
	mean ± SD	3.49 ± 0.52	3.39 ± 0.54	< 0.001	3.50 ± 0.55	3.44 ± 0.54	0.05
	median [p25, p75]	3.5 [3.2, 3.8]	3.4 [3.1, 3.8]		3.6 [3.2, 3.9]	3.5 [3.1, 3.8]	
Charlson comorbidity index score							
	mean ± SD	6 ± 2	5 ± 2	< 0.001	6 ± 2	6 ± 2	0.24
	median [p25, p75]	6 [4, 7]	5 [4, 7]		6 [4, 7]	5 [4, 7]	
Index month	n						
1		1266	1266		167	167	
2		716	716		177	177	
3		508	508		106	106	
4		338	338		112	112	
5		246	246		64	64	
6		195	195		50	50	

Abbreviations: BSI, blood stream infection; ESRD, end-stage renal disease; nPCR, normalized protein catabolic rate; SD, standard deviation

Figure 1: Differences in Clinical Utilization among CVC Patients with versus without BSI and CVC Patients with versus without Occlusion



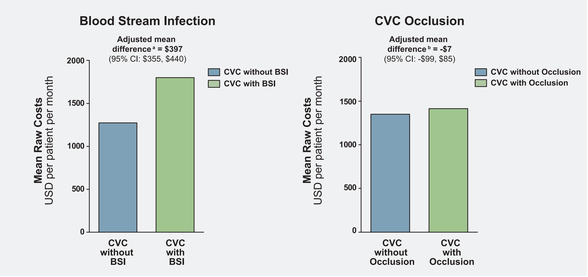
[a] Adjusted for age, weight, serum albumin, normalized protein catabolic rate, Charlson comorbidity index score, etiology of ESRD, and payor.
[b] Adjusted for sex, serum albumin, and payor.
Abbreviations: BSI, bloodstream infection; CI, confidence interval; IRD, incidence rate difference; ESA, erythropoiesis-stimulating agent

Table 2: Comparative Clinical Utilization among CVC Patients with or without BSI and Among CVC Patients with or without Occlusion

	CVC without BSI N = 3269	CVC with BSI N = 3269	*P*-Value	CVC without Occlusion N = 676	CVC with Occlusion N = 676	*P*-Value
At-risk time, patient-months	11207	11858		2349	2440	
Missed Treatments						
Events	15235	23136		3614	3777	
Rate, per patient-month	1.36	1.95		1.54	1.55	
IRD (95% CI)	0 (Ref)	0.59 (0.50, 0.68)	< 0.001	0 (Ref)	0.009 (-0.168, 0.187)	0.92
Adjusted IRD (95% CI)	0 (Ref)	0.35 (0.28, 0.41) [a]	< 0.001	0 (Ref)	-0.053 (-0.199, 0.093) [b]	0.48
ESA						
Monthly Utilization						
Mean ± SD	49,515 ± 48,969	59,339 ± 52,752		48,503 ± 48,867	51,807 ± 49,270	
Median	35,200	46,200		35,200	38,500	
[p25, p75]	[13,200, 70,400]	[19,800, 85,800]		[13,200, 66,000]	[14,850, 73,700]	
Monthly Use						
Number of Users (%)	9709 (86.6)	10628 (89.6)		2070 (88.1)	2135 (87.5)	
Risk difference (95% CI)	0 (Ref)	0.030 (0.018, 0.042)	< 0.001	0 (Ref)	-0.006 (-0.034, 0.022)	0.67
Adjusted risk difference (95% CI)	0 (Ref)	0.024 (0.013, 0.035) [a]	< 0.001	0 (Ref)	-0.020 (-0.053, 0.012) [b]	0.22
Monthly Dose						
Mean ± SD	57,155 ± 48,283	66,207 ± 51,479		55,040 ± 48,477	59,208 ± 48,333	
Median	42,900	52,800		41,800	46,200	
[p25, p75]	[22,000, 78,100]	[26,400, 92,400]		[19,800, 71,500]	[22,000, 81,400]	
Mean difference	0 (Ref)	7366 (5636, 9096)	< 0.001	0 (Ref)	3160 (-381, 6700)	0.08
Adjusted mean difference	0 (Ref)	4389 (2781, 5997) [a]	< 0.001	0 (Ref)	1755 (-2010, 5521) [a]	0.36
IV Iron						
Monthly Utilization						
Mean ± SD	261.5 ± 259.3	266.8 ± 270.0		253.3 ± 248.7	257.4 ± 245.2	
Median [p25, p75]	200 [100, 300]	200 [100, 350]		200 [100, 300]	200 [100, 300]	
Monthly Use						
Number of Users (%)	9187 (82.0)	9450 (79.7)		1896 (80.7)	2021 (82.8)	
Risk difference (95% CI)	0 (Ref)	-0.023 (-0.038, -0.007)	0.004	0 (Ref)	0.021 (-0.012, 0.054)	0.21
Adjusted risk difference (95% CI)	0 (Ref)	-0.018 (-0.031, -0.005) [a]	0.007	0 (Ref)	0.016 (-0.015, 0.047) [b]	0.32
Monthly Dose						
Mean ± SD	318.9 ± 252.4	334.8 ± 262.1		313.8 ± 240.1	310.8 ± 236.7	
Median [p25, p75]	200 [200, 400]	200 [200, 400]		200 [200, 400]	[200, 400]	
Mean difference	0 (Ref)	7.65 (1.43, 13.88)	0.02	0 (Ref)	-2.96 (-15.13, 9.22)	0.63
Adjusted mean difference	0 (Ref)	4.88 (-1.49, 11.26) [a]	0.13	0 (Ref)	-3.86 (-16.53, 8.82) [b]	0.55
Thrombolytics						
Monthly Use						
Number of Users (%)	493 (4.4)	653 (5.5)		99 (4.2)	265 (10.9)	
Risk difference (95% CI)	0 (Ref)	0.011 (0.004, 0.018)	0.003	0 (Ref)	0.066 (0.047, 0.086)	< 0.001
Adjusted risk difference (95% CI)	0 (Ref)	0.010 (0.001, 0.019) [a]	0.03	0 (Ref)	0.067 (0.041, 0.092) [b]	< 0.001
Antibiotics						
Monthly Use						
Number of Users (%)	667 (6.0)	4954 (41.8)		233 (9.9)	308 (12.6)	
Risk difference (95% CI)	0 (Ref)	0.358 (0.347, 0.369)	< 0.001	0 (Ref)	0.027 (0.003, 0.051)	0.03
Adjusted risk difference (95% CI)	0 (Ref)	0.352 (0.336, 0.369) [a]	< 0.001	0 (Ref)	0.019 (-0.002, 0.040) [b]	0.08

[a] Adjusted for age, weight, serum albumin, normalized protein catabolic rate, Charlson comorbidity index score, etiology of ESRD, and payor.
[b] Adjusted for sex, serum albumin, and payor.
Abbreviations: BSI, blood stream infection; CI, confidence interval; ESA, erythropoiesis-stimulating agent; IRD, incidence rate difference; IV, intravenous; SD, standard deviation

Figure 2: Monthly Variable Costs to Dialysis Providers in CVC Patients with or without BSI and CVC Patients with or without Occlusion



[a] Adjusted for age, weight, serum albumin, normalized protein catabolic rate, Charlson comorbidity index score, etiology of ESRD, and payor.
[b] Adjusted for sex, serum albumin, and payor.
Abbreviations: BSI, bloodstream infection; CI, confidence interval; CVC, central venous catheter; USD, US dollars

Conclusions

- CVC-related BSI is a potent cost driver for dialysis providers. Effects are mediated by:
  - Missed HD treatments
  - ESA utilization
  - IV antibiotic utilization
- Total costs to the dialysis provider were approximately $2,400 per BSI episode over the 6-month time horizon.
- CVC occlusion did not have appreciable economic consequences from the provider perspective.

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