CJASN ePress. Published on April 19, 2006 as doi: 10.2215/CJN.01401005

Associations between Demographic Factors and Provider Structures on Cost and Length of Stay for Hemodialysis Patients with Vascular Access Failure

Louis Brenner,*†‡ Ajay K. Singh,* Dennis Campbell,†§ Frances Frei,† and Wolfgang C. Winkelmayer*‖

**Renal Division and ‖Division of Pharmacoepidemiology and Pharmacoeconomics, Brigham and Women's Hospital and Harvard Medical School, and †Technology and Operations Management Unit and §Accounting and Control Unit, Harvard Business School, Boston, and ‡Renal and Transplant Business Units, Genzyme Corporation, Cambridge, Massachusetts*

Vascular access failure (VAF) is a major determinant of morbidity and cost for hemodialysis patients, but little is known about the care patterns and cost implications that are associated with VAF. A total of 952 episodes of VAF in 348 patients were identified using specific procedure codes. Demographic and care pattern characteristics were available as were detailed costs for each episode. The determinants of several important performance measures were evaluated: Cost per episode, inpatient *versus* outpatient treatment, and length of stay (LOS). Over 5 yr of study, the proportion of VAF episodes that were treated on an outpatient basis increased from 31 to 63%. Average costs of outpatient *versus* inpatient episodes were $1491 and $8265, respectively. Men were more likely to be treated as outpatients (odds ratio [OR] 1.56; 95% confidence interval [CI] 1.17 to 2.08), but once admitted, their LOS was longer (difference LOS +1.3; 95% CI +0.32 to +2.28) and more costly (Δ$ +2603; 95% CI +632 to +4573). Nonblack, nonwhite patients were more likely to be treated as outpatients than were white patients (OR 2.07; 95% CI 1.27 to 3.36) and had shorter LOS once admitted (ΔLOS −2.37; 95% CI −4.23 to −0.49). Compared with Medicare, non-Medicare case-managed insurance was associated with a higher likelihood of outpatient treatment (OR 1.40; 95% CI 1.01 to 1.94) for VAF and shorter LOS (ΔLOS −1.36; 95% CI −2.48 to −0.24) and lower costs (Δ$ −2742; 95% CI −5012 to −472) for inpatient treatment. It is concluded that gender and racial factors may influence VAF care. Over time, more VAF episodes are being treated in outpatient settings. Case management may lead to more outpatient treatment and shorter inpatient treatment of VAF.

Clin J Am Soc Nephrol 1: 455–461, 2006. doi: 10.2215/CJN.01401005

Creation and maintenance of peripheral vascular access for hemodialysis is a major source of patient morbidity and an important cost determinant for payers of hemodialysis services in the United States. Feldman *et al.* (1) demonstrated that 25% of hospitalizations for hemodialysis patients were due to vascular access failure (VAF) and that 50% of the cost of the first year of hemodialysis was due to problems with vascular access. Data from the United States Renal Data System (USRDS) Dialysis Morbidity and Mortality Study Wave 1 showed that vascular access care costs ranged between $6228 and $7871 per hemodialysis patient per year (2). According to USRDS estimates, the total cost of caring for patients with ESRD in the United States in 1998 was $16.74 billion, with approximately 72% of the cost, or $12.04 billion, being paid by the federal government *via* the Medicare ESRD program (3). Because vascular access care accounts for approximately 15% of the total annual costs per hemodialysis patient (2), the total annual cost for vascular access care in the United States can be estimated conservatively at $2.5 billion, with approximately $1.8 billion being paid for by the federal Medicare ESRD program.

With the ESRD population growing steadily, vascular access–related morbidity and cost are receiving increased attention. Although the National Kidney Foundation's Dialysis Outcomes Quality Initiative guidelines state that a native arteriovenous (AV) fistula is the preferred type of hemodialysis access (4), polytetrafluoroethylene AV grafts remain the most frequently used form of hemodialysis access in the United States, including 66% of the patients in the Hemodialysis (HEMO) study and 58% of prevalent US hemodialysis patients in the Dialysis Outcomes and Practice Patterns Study (DOPPS) (5,6). However, despite the preponderance of synthetic grafts relative to native vein fistulas, grafts are more prone to complications and associated with increased mortality (7). The patency rate of AV grafts is approximately 49% at 1 yr and 30% at 2 yr (6,8), and patients who receive dialysis *via* an AV graft must undergo, on average, 1 to 1.5 procedures per year in an effort to treat thromboses and maintain graft function (9). Treatment of graft

Received October 21, 2005. Accepted February 24, 2006.

Published online ahead of print. Publication date available at www.cjasn.org.

Address correspondence to: Dr. Louis Brenner, Renal Division, Brigham and Women's Hospital, MRB-4, 75 Francis Street, Boston, MA 02115. Phone: 617-732-5951; Fax: 617-732-6392; E-mail: lbrenner@partners.org

ISSN: 1555-9041/103-0455

thrombosis often leads to hospitalization, missed outpatient dialysis sessions, and a sequence of interventional procedures to restore functional vascular access.

Recent approaches to lessen the morbidity and costs that are associated with AV access failure have focused on prevention of acute AV access thromboses. The HEMO study has suggested that black race, female gender, obesity, and advanced age each are independently associated with a lower likelihood of having a desired AV fistula, so patients in these demographic groups should receive extra attention at the time of vascular access creation (5). A recent study demonstrated the ability of a collaborative care pathway, led by a clinical nurse specialist, to contain costs and hospitalization days that are associated with planned AV access surgery (10). Vascular access blood flow monitoring techniques provide early detection of vascular access malfunction, leading to planned corrective intervention and sparing the costs, morbidity, and missed dialysis that are associated with acute thrombosis (11). Although these AV access thrombosis prevention initiatives have been modestly successful, there also is an important opportunity to limit morbidity and costs for patients after an acute AV access thrombosis has occurred. Just as demographic factors, case managers, and care pathways have been shown to influence initial vascular access placement and costs, their effects on the morbidity and costs that are associated with subsequent vascular access complications should be examined.

We conducted this study with two objectives in mind. First, we sought to define better the costs of caring for patients with thrombosed AV access. Previous large-scale efforts, including the USRDS analyses, have focused on large, population-based samples, and cost data were derived from Medicare claims. By contrast, we sought to determine accurately costs that are attributable to failed AV access using patient and fiscal data from a single institution. Specifically, our institution recently implemented an Activity-Based Cost (ABC) accounting system, which allows for the accurate determination of the true costs of providing care, independent of Medicare or insurance reimbursement. Our second objective was to identify how demographic, insurance provider, and institutional factors affect morbidity and costs for patients with thrombosed AV access.

Materials and Methods

Study Population

This study was approved by the Institutional Review Board of our institution. We identified all episodes of AV access failure in hemodialysis patients who presented to Brigham and Women's Hospital between January 1996 and November 2000. We first searched the hospital's information database for the following *International Classification of Diseases, Ninth Revision* and Current Procedural Terminology-4 procedure codes to identify all patients with new access creations: 39.27 (dialysis arteriovenostomy) and 36830 (AV graft). Among these patients, we searched for subsequent encounters with the following codes to identify particular episodes in which patients were treated for AV access failure: 39.42 (revision renal dialysis shunt), 996.73 (complications dialysis graft), 39.50 (noncoronary angioplasty), 88.67 (contrast phlebogram), G0159 (percutaneous declot/thrombectomy), 36145 (catheter placement in graft), 75790 (shunt angiogram), C1326 (AngioJet device for thrombectomy), 36831 (thrombectomy), 36833 (thrombectomy plus revision), 996.74 (clotted AV fistula/AV graft), 36832 (revision AV fistula/AV graft), and 996.1 (mechanical complication).

By study design, we did not consider any episodes that included intensive care unit admission or episodes for which cost exceeded $100,000 or whose length of stay (LOS) was >45 d; this was done under the assumption that such episodes likely would be rooted in disease processes that were unrelated to AV access failure or vascular access for such episodes was a consequence of another catastrophic disease episode. We also removed all episodes for which insufficient clinical and fiscal data were available.

Description of Cost Accounting System/Database Development

Brigham and Women's Hospital's ABC system, introduced in 1996, attempts to assign accurately both direct (unit cost of direct production input) and indirect (including allocated overhead) costs for hospital facilities and services that are used in caring for individual patients. The ABC system (release 2.6; Transition Systems Inc. [TSI], Boca Raton, FL) allows for departmental development of unit costs for supplies, services, and labor and then determines the actual cost to care for a given patient by assessing the patient's utilization of departmental and hospital resources. Therefore, true costs rather than charges are available for study. With this resource, we created a novel database that encompasses both clinical and fiscal data for all episodes of AV access failure. We focused our analyses on the level of the individual thrombosis episode to dissect the process of care. For each episode, we recorded demographic variables (age, gender, race, and diabetes status), institutional factors (insurance payor, case-managed insurance or non–case-managed insurance, and emergency department [ED] treatment or no ED treatment), and outcomes measures (inpatient or outpatient treatment of the episode, actual cost based on the TSI system, and LOS in hours and days for inpatients).

Statistical Analyses

We defined several variables for each unique thrombosis episode. We recorded each patient's age at presentation and separated patients into four age groups: <45, 45 to <65, 65 to <75, and ≥75 yr. Patient race was categorized into black; white; and other, which included Hispanic, Asian, and Native American. Patients were stratified further by whether they were treated as outpatients *versus* inpatients, the latter including patients who were treated under admit-to-observe status. Episodes also were grouped by primary insurance provider, including both Medicare and non-Medicare payers. Medicare is a federally funded and administered health insurance system; eligibility to enroll in Medicare includes age ≥65 yr as well as ESRD independent of age. Medicare typically uses a fee-for-service reimbursement system for their ESRD-related services. For the non-Medicare group, we noted whether a conventional case-managed model of care was used. The route of hospital entry also was segmented according to whether the patient was cared for in the ED during the episode (episodes could become characterized as either inpatient or outpatient after ED treatment). We used Data Desk (version 6.0, Stata Corp., College Station, TX) and the SAS statistical analysis software (version 8.1; SAS Institute, Cary, NC) for statistical analysis. *T* test and Pearson χ^2 test were used for the comparison of continuous and categorical variables across groups, respectively. We conducted multivariate logistic regression analyses for the outcome of inpatient *versus* outpatient treatment and reported odds ratios (OR) and the corresponding 95% confidence intervals (CI). We used multiple linear regression for the continuous outcomes such as LOS and episode cost. We also tested for interactions

between diabetes and other exposure variables of interest on these outcomes.

Results

Patient Characteristics at the Time of AV Access Failure

From the information database, we identified 952 unique episodes of AV access failure in 348 patients (mean 2.7 per patient; range 1 to 16). Of these, five (0.5%) episodes whose costs exceeded $100,000 were excluded (range $108,521 to $915,514); no episodes were excluded because of an intensive care unit stay or a total LOS of >45 d. After removal of 49 (5.1%) episodes with missing data, 898 unique episodes were available for study. At the time of AV access thrombosis episode, 166 (18.5%) patients were <45 yr, 344 (38.3%) were between 45 and 65 yr, 245 (27.3%) were between 65 and 75 yr, and 143 (15.9%) were 75 yr or older (Table 1). Both genders were nearly equally represented (48.8% women, 51.2% men) as were patients without *versus* with diabetes (48 *versus* 52%). Approximately 40% were white, 48% were black, and 12% were of other race. In terms of route of care, approximately 10% of the episodes utilized treatment in the ED. Medicare was the payor for 476 (53%) episodes. Among the remaining 422 episodes, 259 (61.4%) used a conventional case management model.

Outpatient versus Inpatient Care Performance Measure

Over the 5 yr of study, the rate of AV access failure episodes that were treated on an outpatient *versus* inpatient basis increased from 31 to 63% ($P < 0.001$; Figure 1), consistent with both our institutional and national efforts to shift vascular access care from the inpatient to the outpatient setting. Whereas 53.6% of patients who were younger than 45 yr were treated as outpatients, this proportion declined to 41.3% in the oldest age group (≥75 yr; $P = 0.03$; Table 1). Similarly, men were more likely to be outpatients than women, and patients of other race (Hispanic, Asian, or Native American) were more likely to be outpatients than black or white patients (both $P < 0.001$). Medicare patients were statistically more likely to be inpatients than non-Medicare patients, as were patients who were treated in the ED (Table 1).

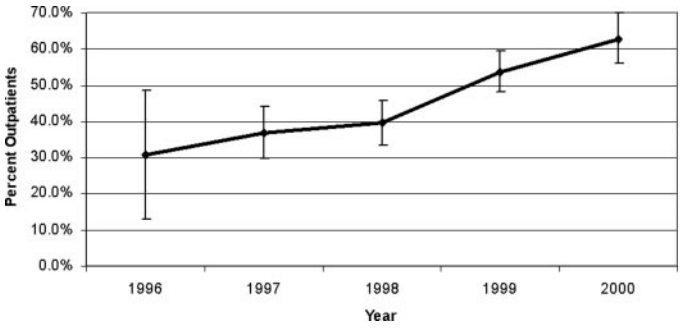

Figure 1. Trends in outpatient *versus* inpatient treatment of arteriovenous access thrombosis. Proportion and 95% confidence interval of patients who were treated as outpatients, by calender year; $P < 0.001$ for trend.

Table 1. Characteristics of 898 episodes of AV access thrombosis[a]

Characteristic	*n* (%)	Outpatient Treatment (%)	*P*
Age (yr)			
<45	166 (18.5)	53.6	—
45 to <65	344 (38.3)	48.5	0.28
65 to <75	245 (27.3)	49.4	0.40
≥75	143 (15.9)	41.3	0.03
Female	438 (48.8)	42.0	—
Male	460 (51.2)	54.7	<0.001
Race			
white	360 (40.1)	45.8	—
black	434 (48.3)	46.5	0.84
other	104 (11.6)	66.3	<0.001
No diabetes	431 (48.0)	48.9	—
Diabetes	467 (52.0)	48.2	0.82
No ED treatment	811 (90.3)	52.6	—
ED treatment	87 (9.7)	11.5	<0.001
Medicare, no CM	476 (53.0)	45.7	—
Non-Medicare, CM	259 (28.8)	52.5	0.039
Non-Medicare, no CM	163 (18.2)	50.9	0.037

[a]AV, arteriovenous; ED, emergency department; CM, case management.

From a multivariate logistic regression analysis of the outpatient *versus* inpatient performance measure (Table 2), we found that men were 56% more likely to be treated as outpatients compared with women (OR 1.56; 95% CI 1.17 to 2.08). Similarly, patients of other race were twice as likely to be outpatients compared with white patients (OR 2.07; 95% CI 1.27 to 3.36). Patients who were seen in the ED were dramatically less likely to be treated as outpatients (OR 0.12; 95% CI 0.06 to 0.24). Non-Medicare patients were approximately 40% more likely to be outpatients than Medicare patients in these multivariate models, independent of whether they were case managed (Table 2).

Cost and LOS Performance Measures

As expected, there was a significant difference between the mean actual costs of caring for AV access failure in the inpatient *versus* the outpatient setting ($8265 *versus* $1491; $P < 0.001$; Figure 2). Among the 462 patients who were admitted for AV thrombosis treatment, men had an average LOS of 3.52 d, whereas women stayed for 2.4 d, on average ($P = 0.02$; Table 3), which translated into mean costs of $7175 and $9595, respectively ($P = 0.01$). White patients stayed longer than black patients or patients of other race. The most striking difference was found between patients who were treated in the ED compared with those who were not. The former had an average LOS of 5.86 d and incurred costs of $12,106 compared with 2.32 d and $7397 in the latter group ($P < 0.001$). A trend toward shorter LOS and lower costs for case-managed patients was observed, but this difference did not reach statistical significance (Table 3).

We examined the independent correlates of differences in LOS (ΔLOS) and cost (Δ$) using multivariate linear regression analysis (Table 4). We analyzed these outcome measures sepa-

Table 2. Independent correlates of outpatient *versus* inpatient treatment[a]

Covariate	OR for Outpatient *versus* Inpatient Treatment	95% CI	*P*
Age (yr)			
<45	1.0	Referent	—
45 to <65	0.81	0.55 to 1.21	0.30
65 to <75	0.94	0.60 to 1.45	0.77
≥75	0.74	0.45 to 1.22	0.24
Female	1.0	Referent	—
Male	1.56	1.17 to 2.08	0.002
Race			
white	1.0	Referent	—
black	1.14	0.82 to 1.58	0.44
other	2.07	1.27 to 3.36	0.003
No diabetes	1.0	Referent	—
Diabetes	1.00	0.75 to 1.34	0.98
No ED treatment	1.0	Referent	—
ED treatment	0.12	0.06 to 0.24	<0.001
Medicare, no CM	1.0	Referent	—
Non-Medicare, CM	1.40	1.01 to 1.94	0.05
Non-Medicare, no CM	1.41	0.96 to 2.08	0.08

[a]CI, confidence interval; OR, odds ratio.

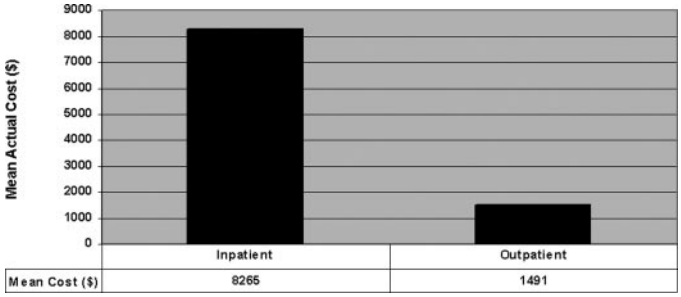

Figure 2. Mean actual cost per thrombosis episode, inpatient *versus* outpatient care.

rately without controlling for LOS in the cost model, as these outcomes exhibit significant collinearity. For inpatients, male gender was correlated with longer LOS (ΔLOS +1.3 d; 95% CI +0.32 to + 2.28) and higher costs (Δ$ +2603; 95% CI +632 to + 4573) compared with female gender. White race was associated with longer LOS and higher costs in the multivariate model (Table 4). ED treatment was associated with significantly longer LOS (ΔLOS +3.71 d; 95% CI +2.46 to +4.96) and higher costs (Δ$ +4930; 95% CI +2409 to +7449). Finally, in the multivariate model, inpatient case management was correlated with significantly shorter LOS (ΔLOS −1.36 d; 95% CI −2.48 to −0.24) and significantly lower costs ((Δ$ −2742; 95% CI −5012 to −472) compared with Medicare patients for whom no case management was available (Table 4). None of the interaction terms between diabetes and any other variables of interest was statistically significant (all $P > 0.20$).

Discussion

Our study augments the current understanding of the process of vascular access care for hemodialysis patients. We used an important new resource to define better the costs of providing vascular access care. The implementation and utilization of Brigham and Women's TSI ABC accounting system has allowed us to describe more accurately the costs that are associated with vascular access for patients in both the outpatient and the inpatient setting as compared with previous studies that relied on Medicare claims (2). Therefore, we were able to determine accurately the hospital's cost of providing this care on an episode-by-episode basis, independent of source of reimbursement and thereby avoiding the use of charges that may not reflect true costs. This type of unit analysis, in this case on a patient-by-patient and an episode-by-episode level, has been instructive for service sector companies in fields other than health care, because knowledge of costs to serve, rather than just payment received, has engendered a better understanding and improved efficiency of the service process.

Our cost data fall roughly in line with recent USRDS estimates. Dialysis Morbidity and Mortality Study Wave 1 data from 1994 estimated that annual vascular access care expenditures were between $6228 and $7871 per patient (2). Comparing this with our estimates (Figure 2), patients might present for either one episode of inpatient care ($8265) or four episodes of outpatient care ($1491 each) before meeting or exceeding the annual USRDS estimate. Moreover, our estimates capture hospital costs, including hospital-based hemodialysis treatments, but do not account for professional fees for nephrologists, surgeons, or radiologists. Our cost-accounting data set does not capture these professional fees, but it would seem likely that

Table 3. Hospital LOS and cost for inpatient episodes ($n = 462$)[a]

Covariates	No. (%) of Episodes	LOS (d; ±SD)	*P*	Mean Actual Cost ($; ±SD)	*P*
Age (yr)					
<45	77 (16.7)	2.40 ± 3.95	—	7,162 ± 7,463	—
45 to <65	177 (38.3)	2.69 ± 4.86	0.69	7,952 ± 9,855	0.58
65 to <75	124 (26.8)	3.46 ± 7.04	0.17	9,550 ± 14,051	0.12
≥75	84 (18.2)	3.04 ± 4.23	0.45	8,037 ± 7,884	0.59
Female	254 (55.0)	2.40 ± 2.80	—	7,175 ± 7,445	—
Male	208 (45.0)	3.52 ± 6.67	0.02	9,595 ± 13,259	0.01
Race					
white	195 (42.2)	3.63 ± 6.56	—	9,770 ± 13,199	—
black	232 (50.2)	2.56 ± 4.31	0.04	7,245 ± 8,103	0.01
other	35 (7.6)	1.26 ± 1.92	0.02	6,636 ± 6,282	0.10
No diabetes	220 (47.6)	2.93 ± 5.62	—	8,026 ± 10,694	—
Diabetes	242 (52.4)	2.75 ± 5.02	0.97	8,482 ± 10,390	0.64
No ED treatment	385 (83.3)	2.32 ± 4.67	—	7,497 ± 10,107	—
ED treatment	77 (16.7)	5.86 ± 7.08	<0.001	12,106 ± 11,751	<0.001
Medicare, no CM	258 (55.8)	3.18 ± 5.85	—	8,632 ± 11,286	—
Non-Medicare, CM	123 (26.6)	2.25 ± 4.18	0.11	6,875 ± 6,776	0.13
Non-Medicare, no CM	81 (17.5)	3.05 ± 4.91	0.85	9,243 ± 12,542	0.66

[a]LOS, length of stay.

Table 4. Independent correlates of LOS and cost in inpatient episodes

Covariates	ΔLOS (d)	95% CI	*P*	ΔInpatient Cost ($)	95% CI	*P*
Age (yr)						
<45	Referent	—	—	Referent	—	—
45 to <65	−0.62	−1.60 to +0.34	0.21	+687	−2,077 to +3,451	0.63
65 to <75	−0.24	−1.40 to +0.90	0.67	+2,945	−175 to +6,065	0.06
≥75	−0.55	−1.74 to +0.64	0.37	+403	−3,000 to +3,806	0.82
Female	Referent	—	—	Referent	—	—
Male	+0.1	+0.32 to +2.28	0.009	+2,603	+632 to +4,573	0.01
Race						
white	Referent	—	—	Referent	—	—
black	−0.99	−2.08 to +0.10	0.07	−2,593	−4,790 to −396	0.02
other	−2.37	−4.23 to −0.49	0.01	−3,236	−7,009 to +538	0.09
No diabetes	Referent	—	—	Referent	—	—
Diabetes	+0.06	−0.90 to +1.03	0.90	+738	−1,215 to +2,690	0.46
No ED treatment	Referent	—	—	Referent	—	—
ED treatment	+3.71	+2.46 to +4.96	<0.001	+4,930	+2,409 to +7,449	<0.001
Medicare, no CM	Referent	—	—	Referent	—	—
Non-Medicare, CM	−1.36	−2.48 to −0.24	0.02	−2,742	−5,012 to −472	0.02
Non-Medicare, no CM	−0.10	−1.46 to +1.25	0.88	+667	−2,065 to +3,398	0.63

these fees would add to the total costs of a particular episode of AV graft failure. In addition, our data do not capture the costs of missed outpatient dialysis and unused outpatient dialysis capacity during inpatient vascular access care episodes.

Our study highlights interesting trends and poses several important questions regarding the demographic factors that affect vascular access care. Although age was not associated with any of the care measures studied, men were more likely to be treated as outpatients than women, but once admitted, men were hospitalized longer and incurred higher costs. This could be interpreted as a bias to treat female episodes of AV access failure in an inpatient setting, independent of the complexity of the case or the acuity of the situation. Is there truly a perception that female patients with ESRD should be or need to be admit-

ted for AV access failure more than their matched male counterparts? At a minimum, this suggests that there is an opportunity increasingly to shift vascular access care for women to the outpatient setting. Clearly, our work raises hypotheses that need to be tested thoroughly in future research. We did not find any differences between outcome measures for patients with *versus* without diabetes. Because diabetes frequently is referred to as a driver of higher costs and as a predictor of vascular access complications in patients with ESRD, this finding was somewhat surprising. We also did not detect any effect modification of diabetes on the associations between case management and the outcomes studied. Therefore, the assumption that our findings pertain to both patients with and without diabetes holds.

Our analysis generates perhaps its most intriguing demographic questions with regard to racial influences on vascular access care. We found a statistically significant lower likelihood of inpatient treatment for patients in the nonblack, nonwhite race category, when compared with both black and white patients. This may reflect a systemic bias against admitting these predominantly Hispanic or Asian patients or may reflect an unwillingness of these patients to be admitted. These patients are more likely to be non-native English speakers or non-English speakers, so communication barriers regarding treatment options and patient fears of communication difficulties during hospitalization might be reflected in this observation.

Recent large-scale studies have yielded conflicting results with respect to racial differences in vascular access care. Whereas the USRDS and DOPPS studies found no differences in fistula frequency across races in incident hemodialysis patients (12,13), the HEMO study found a statistically significant difference (5). Our study approaches the issue of racial differences in vascular access care from another angle, focusing on all AV access types rather than fistulas, prevalent rather than incident patients, and a single rather than multiple study centers. We found that black inpatients had significantly shorter LOS and consequently lower costs than white patients. Because black patients tend to have longer life spans than white patients once on hemodialysis, we might expect prevalent vascular access care for black patients to be more complicated than for white patients, based on longer hemodialysis vintage, but we found the opposite. Black patients do tend to have higher body mass indexes while on hemodialysis; therefore, their vasculature may allow for less complicated access care (14,15). It also may reflect differences in comfort with hospitalization between black and white patients, as black patients themselves might have a preference for earlier hospital discharge. However, these differences also might reflect racial disparity in care between black and white patients, similar to that documented in the cardiovascular and renal transplantation literature (16–18). A possible mechanism to explain the shorter inpatient LOS for black patients is a lower threshold for placing a new dialysis catheter in black patients, rather than pursuing a more costly and time-intensive attempt to salvage or reconstruct a failed graft. A deeper investigation of the end of the episode's resultant type of vascular access in our population might sort out this issue, but more studies are needed to investigate racial disparities in access care for prevalent patients. Because recent studies have pointed to racial disparities in the likelihood of renal transplantation for prevalent patients with ESRD (18), it also is important to investigate racial disparities in vascular access care for prevalent patients, especially because the same institutional and practice pattern biases may be present in both renal transplantation and vascular access care.

In addition to the demographic factors discussed above, we have shown that provider structure and route of care can exert significant influence on the costs and LOS for a patient who presents with AV graft failure. Not surprising, our ED utilization analysis found a much higher likelihood of admission after ED treatment, as more acutely ill patients are likely to be sent to the ED. This ED treatment correlated with longer LOS and higher costs in multivariate regression analyses. The role of the ED potentially as a triage resource or a holding area for outpatient vascular access care merits further investigation.

Our study also underscores the current role of and future opportunities for case management to have a salutary impact on vascular access care. We found a trend toward outpatient rather than inpatient care for case-managed episodes, and we found that case management was associated with significantly reduced costs of inpatient AV access failure episodes by reducing LOS. Table 4 shows mean costs in case-managed patients that were $2742 lower than in non–case-managed Medicare patients. A simple break-even analysis for a case manager, assuming a generous $100,000 annual salary and benefit package and a $2742 savings per admitted patient with case management, yields a break-even volume of 37 inpatients annually for a vascular access program to recoup its investment in a case manager. Moreover, this analysis does not even take into account the approximately $7000 saved each time a case manager is able to coordinate outpatient rather than inpatient vascular access care. Last, with the recent realization of the potential for cost savings with vascular access blood flow monitoring (11), the role and the importance of a case manager for vascular access care is likely to increase even further.

Although our study adds intriguing fiscal data to the vascular access literature, we are cognizant of its limitations. Some of these criticisms, however, highlight the potentially unique contributions and strengths of our approach. First and foremost, because this study is cross-sectional by design, the associations that we describe do not necessarily constitute cause and effect. Our episode identification strategy relied on a historical database search using a procedure code algorithm. Therefore, we may have missed episodes that could have been included in our data set, and we may have included inappropriately other episodes in the data set. The uniformity and the validity of the episodes studied depends on the procedure and diagnosis codes that were ascribed to the episodes at the time of treatment by the nephrologists, transplant surgeons, vascular radiologists, and coding staff at Brigham and Women's Hospital. Because these professionals constitute a well-defined group and our institutional coding practices are strictly standardized, it is likely that the episodes that were included in the data set represent a legitimate sample of cases of AV access failure that were treated at our institution. Our data collection algorithm

did not allow us to distinguish between failed grafts and failed AV fistulas. This study is not suitable to disentangle the contributions of several co-occurring trends. As more and more care is shifted to the outpatient setting, one might assume that more complicated and costlier episodes are retained for inpatient care. Therefore, one would assume that inpatient care also would become more expensive over time. This putative tendency, however, is overlaid by a similar tendency to reduce LOS and the associated costs. The general application of our findings to other institutions or care systems is uncertain, because it is possible that our institution might attract more difficult cases. However, when compared with a national database such as the USRDS, our approach is bolstered by uniform local standards and procedures for vascular access care as well as by a unique cost-accounting system that enables us to assign more accurately actual costs than can be captured from Medicare claims.

Last, this retrospective investigation is not influenced by the Hawthorne effect, in which knowledge of the study might influence the behavior of the participants and therefore bias the results. In our efforts to categorize retrospectively the process of care, we used the likelihood of outpatient treatment, actual cost, and LOS as outcome measures.

Conclusion

In this study, we interrogated the underlying processes and drivers of costs that are associated with vascular access care for hemodialysis patients. This was accomplished by using the Brigham and Women's TSI ABC accounting system rather than relying on Medicare claims. The importance of demographic factors, provider structure and route of care, and the use of disease management resources seem to play important roles in determining cost. Ultimately, such information should inform the development and the implementation of a data-driven care pathway that will allow for patient-friendly, cost-conscious, and time-sensitive solutions to the difficult problem of reestablishing vascular access after AV access thrombosis. Future and more definitive prospective studies will be needed to confirm our findings and to inform policy formulation.

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