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Early physician follow-up and out of hospital outcomes after cerebral aneurysm treatment in the elderly

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Abstract

Background—The impact of early physician follow-up on out-of-hospital outcomes after cerebral aneurysm treatment has not been studied before. We investigated the association of early physician follow-up (within 30 days of discharge) with mortality and readmissions for elderly patients undergoing treatment for unruptured and ruptured cerebral aneurysms.

Methods—We performed a cohort study of 100% of Medicare fee-for-service claims data for elderly patients who underwent treatment for cerebral aneurysms from 2007 to 2012. In order to control for confounding, we used propensity score conditioning and inverse probability weighting, with mixed effects to account for clustering at the HRR level.

Results—Of the 8,703 patients presenting with unruptured aneurysms, 5,673 (65.2%) had early physician follow-up, and 3,030 (34.8%) did not. Of the 3,211 patients presenting with subarachnoid hemorrhage, 1,504 (46.8%) had early physician follow-up, and 1,707 (53.2%) did not. Propensity score adjusted analysis demonstrated that patients treated for unruptured aneurysms, who visited a physician within 30 days of discharge had lower 3-month mortality (OR, 0.52; 95% CI, 0.36 to 0.74), but a higher rate of 90-day readmissions (OR, 1.14; 95% CI, 1.03–1.28). Similarly, early follow-up was associated with lower 3-month mortality (OR, 0.33; 95% CI, 0.24 to 0.46), and a higher rate of 90-day readmissions (OR, 1.79; 95% CI, 1.02–3.14) for patients presenting with SAH.

Conclusions—In a cohort of Medicare patients undergoing treatment for cerebral aneurysms, we identified an association of early physician follow-up with decreased short-term post-discharge

mortality, but increased 90-day readmissions. More studies on the impact of strengthening the post-discharge network on the outcomes of this population are warranted.

Keywords

cerebral aneurysm; subarachnoid hemorrhage; follow up; post-acute care; Medicare

INTRODUCTION

As the practice of medicine is shifting from authority to accountability,² surgeons are under increasing scrutiny for the outcomes of their interventions. The Centers for Medicare and Medicaid Services (CMS) is tracking several quality metrics in this population.^{6–8} Recently enacted legislation¹⁰ has created multiple avenues for public reporting and has linked appropriate benchmarking to reimbursement.^{6–8} Although quality reporting, if done appropriately, can empower all healthcare shareholders, the process is commonly criticized because surgeons are sometimes held accountable for parts of care that are not under their immediate control.¹⁴ Short-term mortality and readmissions are commonly such tracked measures.³ Especially in frail surgical groups, such as the elderly, these outcomes are likely to depend more on the quality of the patients' post-discharge network, than the care they received in the hospital or the skill of the surgeon.

However, little attention has been paid to the impact of this post-discharge network on short-term surgical outcomes. A prior investigation in medical patients hospitalized for congestive heart failure has demonstrated that early post-discharge follow-up was associated with decreased rate of readmissions.¹¹ The authors hypothesized that optimizing these patients' outpatient pharmacologic treatment during follow-up yielded such positive results.¹¹ There has been no prior study investigating the impact of early physician follow-up on the outcome of neurosurgical procedures in the elderly.

We performed a national cohort study of Medicare patients with cerebral aneurysms, investigating the association of early physician follow-up on 90-day mortality, and 90-day readmission. We utilized a battery of approaches to control for confounding, including regression adjustment, propensity score adjustment, and inverse probability weighting (IPW), whereas mixed effects methods were employed to control for clustering at the Hospital Referral Region (HRR) level.

METHODS

Data and cohort creation

This study was approved by the Dartmouth Committee for Protection of Human Subjects. The data was anonymized and de-identified prior to use and therefore no informed consent was required. We used 100% of Medicare Denominator file and corresponding Medicare inpatient and outpatient claims, Parts A and B, 2007–2012 (MedPAR, Carrier and Outpatient files) to select patients with cerebral aneurysm diagnosis. Aneurysm patients were identified based on one or more inpatient or outpatient diagnoses (*International Classification of Diseases, Ninth Revision* (ICD-9) diagnosis code 437.3) between 2007 and 2012. For

cohort inclusion, patients were required to be (1) continuously enrolled in fee-for-service (FFS) Medicare Parts A, and B for 12 months before index diagnosis, and (2) be age 65 or older at the time of index diagnosis.

Intervention

We used ICD-9-CM codes to identify patients with unruptured cerebral aneurysms (ICD-9-CM code 437.3), or ruptured cerebral aneurysms (ICD-9-CM 430), who underwent clipping (ICD-9-CM code 39.51) or endovascular treatment (ICD-9-CM code 39.52 (should also have a code 88.41 and no 39.51 during the same hospitalization), 39.72, 39.75, 39.76 39.79) between 2007 and 2012. Patients with multiple treatments were included in the cohort only after the last treatment.

Outcome variables

The primary outcome was 90-day post-discharge mortality. The secondary outcome was the rate of 90-day post-discharge readmission. These events were recorded after an initial 30-days period post-discharge to account for the period during which follow-up could happen. Only patients surviving after this initial 30-day period were included in the analysis.

Covariates

Early physician follow-up was our exposure variable of interest, and was defined as outpatient follow-up (with physicians or advanced practice providers) within 30-days of discharge after cerebral aneurysm treatment. Patients with follow-up after 30-days or no follow-up were used as control.

Sex-age categories (65–69, 70–74, 75–79, 80–84, 85–99) were created, as well as five ethnicity and race categories (Asian, Black, Hispanic, Native American, and other, with white being the excluded variable). The enrollee's ZIP code was used to match to 2010 Census data on income and poverty. We included the ZIP-level poverty rate separately, from the income variable, to reflect the differing distribution of income within the ZIP code. Treatment method (clipping, or endovascular treatment) was also used as a covariate in the regressions.

Comorbidities, diagnosed (in more than 2 outpatient and/or 1 inpatient encounters) at any time in the 12-month look-back (before the intervention), for which outcomes were adjusted (Table S1), included: hypertension, myocardial infarction, cardiac arrhythmia, congestive heart failure, hyperlipidemia, coagulopathy, hypertension, ischemic stroke, peripheral vascular disease, smoking, chronic obstructive pulmonary disease (COPD), other pulmonary disease, diabetes, obesity, alcohol abuse, malignancy, and dementia.

Each facility was identified with one of the 306 Hospital Referral Regions (HRR) in the United States as used by The Dartmouth Atlas of Health Care. An HRR is a region served by a hospital or group of hospitals that offer cardiovascular and neurosurgical procedures, so that each HRR includes at least one tertiary care hospital. All ZIP codes in the United States were assigned to HRR on the basis of the migration patterns of hospital use among the elderly population.

Statistical analysis

To compare outcomes between patients having early physician visits and those without we used several methods to address confounding, two of which are based on propensities. To derive the propensity of seeing a physician within 30-days we developed a prediction model using logistic regression, based on the covariates described above. To compare death at 90 days, and 90-day readmission between patients having early physician follow-up and those without, we employed multivariable logistic regression, logistic regression with adjustment (stratification) by quantiles (we chose the number of quantiles to be 20) of the propensity score, and inverse propensity weighting (IPW) logistic regression. These models included the patient's HRR as a random effects variable to control for clustering. Finally, we plotted the survival of our cohort, using a Kaplan-Meier estimator, stratified for early physician visit, as well as IPW-adjusted Kaplan-Meier.¹²

In sensitivity analysis we considered early follow-up as having a physician visit within 7-days of discharge. We used 30-day mortality, and 30-day readmissions as our outcomes. Additionally, we included discharge disposition from the initial admission as a variable in all our analyses, to control for potentially sicker patients needing rehabilitation, which could concurrently affect the aggressiveness of follow-up. The results of these additional analyses demonstrated the same direction of associations and therefore are not presented any further.

Given that we had 5,673 patients with an early physician visit, and 3,030 without, we had an 80% power to detect a difference in 3-month mortality as small as 1.3%, at an α -level of 0.05. Patients with missing data (3% of poverty and income) were excluded from all analyses. All probability values were the result of two sided tests. The 64-bit version of R. 2.12.2 (R Foundation for Statistical Computing) was used for statistical analysis.

RESULTS

Patient characteristics

Of the 8,703 patients presenting with unruptured aneurysms, 5,673 (65.2%) had early physician follow-up, and 3,030 (34.8%) did not. Of the 3,211 patients presenting with subarachnoid hemorrhage, 1,504 (46.8%) had early physician follow-up, and 1,707 (53.2%) did not. The respective distribution of exposure variables between the two groups for both ruptured and unruptured aneurysms can be found in Table 1.

90-day Mortality

Among patients with unruptured cerebral aneurysms, 71 (1.3%) deaths were recorded between 30 and 90 days in the group with early physician follow-up, and 59 (2.1%) in the group without. As demonstrated in Table 2, early physician follow-up was associated with decreased 90-day post-discharge mortality (OR, 0.60; 95% CI, 0.42 to 0.85) in the unadjusted analysis. This persisted (Table 2) after adjusting for confounders with a multivariable logistic regression model (OR, 0.53; 95% CI, 0.37 to 0.77), propensity score adjustment (OR, 0.52; 95% CI, 0.36 to 0.74), and IPW (OR, 0.59; 95% CI, 0.45 to 0.75). Figure 1A demonstrates an IPW-adjusted Kaplan-Meier plot of the survival during for unruptured aneurysm patients with early physician follow-up and those without.

Among patients with ruptured cerebral aneurysms, 337 (22.4%) deaths were recorded between 30 and 90 days in the group with early physician follow-up, and 789 (46.2%) in the group without. As demonstrated in Table 2, early physician follow-up was associated with decreased 90-day post-discharge mortality (OR, 0.34; 95% CI, 0.24 to 0.46) in the unadjusted analysis. This persisted (Table 2) after adjusting for confounders in a multivariable logistic regression model (OR, 0.33; 95% CI, 0.23 to 0.46), propensity score adjustment (OR, 0.33; 95% CI, 0.24 to 0.46), and IPW (OR, 0.33; 95% CI, 0.26 to 0.42). Figure 1B demonstrates an IPW-adjusted Kaplan-Meier plot of the survival during for ruptured aneurysm patients with early physician follow-up and those without.

90-day readmission

Among patients with unruptured cerebral aneurysms, 1,410 (24.8%) readmissions were recorded in the immediate 90-day post-discharge period for patients with early physician follow-up, and 658 (21.7%) for those without. The five most common readmission diagnoses were headache, seizures, malaise/fatigue, chest pain, and fever. As demonstrated in Table 2 early physician follow-up was associated with increased rate of 90-day readmission (OR, 1.19; 95% CI, 1.07–1.32) in the crude analysis. Multivariable logistic regression modeling (Table 2) confirmed this (OR, 1.15; 95% CI, 1.03–1.28). This persisted after propensity score stratification (OR, 1.14; 95% CI, 1.03–1.28).

Among patients with ruptured cerebral aneurysms, 42 (2.8%) readmissions were recorded in the immediate 90-day post-discharge period for patients with early physician follow-up, and 31 (1.8%) for those without. As demonstrated in Table 2 early physician follow-up was not associated with increased rate of 90-day readmission (OR, 1.54; 95% CI, 0.89–2.68) in the crude analysis. However, in a multivariable logistic regression model (Table 2) early physician follow up was associated with a higher rate of readmissions although the effect was marginally significant (OR, 1.80; 95% CI, 1.02–3.16). This persisted after propensity score stratification (OR, 1.80; 95% CI, 1.02–3.14), and IPW (OR, 1.70; 95% CI, 1.14–2.55).

DISCUSSION

In a cohort of Medicare patients undergoing treatment for cerebral aneurysms, we identified an association of early physician post-discharge follow-up with decreased 90-day mortality, but increased 90-day readmissions. These results were consistent across techniques to control for confounders. In recent years, surgeons are increasingly held accountable for unfavorable outcomes surrounding the immediate post-discharge period.^{6–8} Surgical quality is assessed in bundled episodes of care.⁵ The impact of other post-discharge care on short-term surgical outcomes remains an issue of debate.⁵

Continuity of care has been shown to improve post-discharge surgical outcomes in multiple settings. Bekelis et al, in a cohort from New York State, demonstrated that among those evaluated in the emergency room in the first 30-days after cerebral aneurysm treatment, patients seen in the hospital where the original procedure was performed were faced with lower readmission rates.³ The same was true for patients undergoing spine surgery, or craniotomy for tumor resection. On the contrary, fragmentation of care has been linked to inefficient use of resources in patients with ischemic⁴ and hemorrhagic stroke.¹ However, no

prior study has investigated the impact of strengthening of the post-discharge network for neurosurgical patients on short-term outcomes.

Previous investigations have highlighted the importance of early follow-up in improving short-term outcomes after medical hospitalizations. Hernandez et al¹¹ were able to demonstrate that hospitals with higher rate of early physician follow-up for Medicare beneficiaries with congestive heart failure were associated with a lower rate of 30-day readmissions. Discharge from hospitals in the higher quartiles of early follow-up was associated with lower risk of mortality or readmission compared with the lowest quartile of early follow-up. These analyses were focused on the hospital level and not the patient level, and therefore the adjustment for covariates was not optimal.

Our study purposefully addresses many of these methodologic limitations. First, we created a cohort of almost all elderly patients in the United States, giving a true picture of national practice. Second, we used advanced observational techniques to control for confounding. Multivariable models, and propensity score stratification were used to adjust our analyses for known confounders. The possibility of clustering, which can bias the results of multi-center national studies, was accounted for by using mixed effects methods. Results were consistent across techniques, supporting the validity of the observed associations.

As we found in this study, a central element of transitional care, outpatient follow-up, varies significantly across patients. Early physician follow-up was associated with decreased mortality, although this was done at the expense of increasing readmissions. It is likely that early visits with a physician identified postoperative problems resulting in immediate attention, re-hospitalization, and prevention of mortality. From this aspect, our study provides supporting evidence for the use of post-discharge systems of care. Programs penalizing readmissions by CMS should be reconsidered, given that these events might just reflect an attentive post-discharge network maximizing care for patients in need. Initiatives to encourage early follow-up are ongoing.¹³ Achieving early follow-up may be difficult for some physician practices, but models of care that include nurse practitioners or physician assistants under physician supervision may result in increased access to early care. Early follow-up is a potential measure of quality of a hospital system and the initiatives put in place to create a tightly knit post-discharge care network.

Transitional care is designed to ensure coordination and continuity in health care. Important elements of transitional care include communication between sending and receiving clinicians, preparation of the patient and caregiver for what to expect at the next site of care, reconciliation of medications, follow-up plans for outstanding tests, and discussions about monitoring signs and symptoms of worsening conditions. For elderly patients undergoing cerebral aneurysm treatment, the transition from inpatient to outpatient care can be an especially vulnerable period because of the age of the patients, complex postoperative courses, the large number of comorbid conditions, and the multiple clinicians who may be involved.

Our study has several limitations common to administrative databases. First, this is an observational study, and there is still a possibility of residual confounding. We used multiple

techniques (propensity score stratification, IPW, HRR random effects), yielding consistent results to account for known and unknown confounders. Second, coding inaccuracies can affect our estimates.

Third, claims data do not provide metrics on the postoperative neurologic status of the patients (i.e. modified Rankin score), chronic pain, or quality of life. Therefore we cannot analyze these measures. Additionally, we did not have data on follow-up phone calls by the physician's office postoperatively. Although these cannot be as comprehensive as in-person visits, they are expected to bias our analysis towards the null. Therefore this highlights the importance of the observed associations even further. Fourth, findings among this older, American population may not be generalizable to younger or otherwise dissimilar populations. Fifth, we have no information on aneurysm size and location, which can affect surgical outcomes. However, this is not expected to affect the association of early-physician follow up with outcomes. Lastly, causal inference is hard to establish based on observational data, even when using advanced observational techniques.⁹

Conclusions

The impact of early physician follow-up on out-of-hospital outcomes after aneurysm treatment has not been studied before. We investigated the association of early physician follow-up (within 30 days of discharge) with mortality and readmissions for elderly patients undergoing treatment for cerebral aneurysms. We found that physician follow-up within 30 days was associated with decreased 90-day post-discharge mortality, but an increase in 90-day readmissions. These findings underscore the need for aggressive follow-up of cerebral aneurysm patients in the immediate 30-day post-discharge period in order to optimize care coordination and identify early postoperative problems. More studies on the impact of strengthening the post-discharge network on the outcomes of this population are warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Figure 1. Kaplan-Meier estimates of survival for patients after treatment for unruptured (A), and ruptured (B) cerebral aneurysms. Adjusted estimates are presented. Adjustment was performed with an inverse probability weighted (IPW) logistic regression model.

Table 1

Patient characteristics

	Unruptured aneurysms		Ruptured aneurysms	
	Patients with early physician follow-up [*] N=5,673	Patients without early physician follow-up [*] N=3,030	Patients with early physician follow-up [*] N=1,504	Patients without early physician follow-up [*] N=1,707
Age, mean (SD)	72.3 (5.3)	71.7 (5.1)	74.2 (6.6)	75.0 (6.6)
Male gender	1,440 (25.4%)	815 (26.9%)	375 (24.9%)	433 (25.4%)
African-Americans	360 (6.3%)	240 (7.9%)	162 (10.8%)	181 (10.6%)
Income [*]	\$47,100 (17,200)	\$45,900 (16,700)	\$45,400 (17,600)	\$45,300 (17,900)
Poverty [*]	(9.4%)	(9.8%)	161 (10.7%)	188 (11.0%)
Comorbidities[†]				
Hypertension	3,197 (56.4%)	1,413 (46.6%)	601 (40.0%)	679 (39.8%)
Hyperlipidemia	1,365 (24.1%)	565 (18.6%)	236 (15.7%)	224 (13.1%)
Chronic obstructive pulmonary disease	148 (2.6%)	84 (2.8%)	20 (1.3%)	33 (1.9%)
Myocardial infarction	937 (16.5%)	374 (12.3%)	139 (9.2%)	181 (10.6%)
Cardiac arrhythmia	507 (8.9%)	167 (5.5%)	85 (5.7%)	101 (5.9%)
Coagulopathy	62 (1.1%)	22 (0.7%)	∅	∅
Renal insufficiency	228 (4.0%)	96 (3.2%)	44 (2.9%)	65 (3.8%)
Congestive heart failure	276 (4.9%)	100 (3.3%)	38 (2.5%)	71 (4.2%)
Pulmonary disease [§]	170 (3.0%)	52 (1.7%)	33 (2.2%)	39 (2.3%)
Obesity	43 (0.8%)	22 (0.7%)	∅	∅
Alcohol abuse	∅	∅	∅	∅
Dementia	71 (1.3%)	28 (0.9%)	20 (1.3%)	20 (1.2%)
Ischemic stroke	692 (12.2%)	325 (10.7%)	62 (4.1%)	66 (3.9%)
Diabetes	917 (16.2%)	333 (11.0%)	166 (11.0%)	198 (11.6%)
Peripheral vascular disease	825 (14.5%)	363 (12.0%)	86 (5.7%)	107 (6.3%)
Malignancy	447 (7.9%)	199 (6.6%)	87 (5.8%)	103 (6.0%)

SD: Standard Deviation

Output represents crude numbers and percentages in parentheses

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Within 30 days of discharge

*

The enrollee's ZIP code was used to match to 2010 Census data on income and poverty.

¶

Based on 12-month look-back before the date of the procedure

§

Non COPD

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Output suppressed to comply with the reporting rules of Medicare, which do not allow printing of output involving less than 11 patients

Table 2

Correlation of early physician follow-up with outcomes

Unruptured aneurysms	90-day mortality ^{##}		90-day readmissions ^{##}	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Unruptured aneurysms				
Crude	0.60 (0.42–0.85)	0.004	1.19 (1.07–1.32)	0.013
Multivariable regression [*]	0.53 (0.37–0.77)	<0.001	1.15 (1.03–1.28)	0.011
Propensity score adjustment [*]	0.52 (0.36–0.74)	<0.001	1.14 (1.03–1.19)	0.015
Inverse probability weighting [*]	0.59 (0.45–0.75)	<0.001	1.18 (1.10–1.27)	<0.001
Ruptured aneurysms				
Crude	0.34 (0.24–0.46)	<0.001	1.54 (0.89–2.68)	0.123
Multivariable regression [*]	0.33 (0.23–0.46)	<0.001	1.80 (1.02–3.16)	0.041
Propensity score adjustment [*]	0.33 (0.24–0.46)	<0.001	1.80 (1.02–3.14)	0.042
Inverse probability weighting [*]	0.33 (0.26–0.42)	<0.001	1.70 (1.14–2.55)	0.010

OR: Odds Ratio; 95% CI: 95% Confidence Interval

^{*} Mixed effects; Includes patient's HRR as a random effect variable[†] HRR early physician follow-up rate was used as an instrument of choice of treatment^{##} Analyses based on logistic regression