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Examination of the Patient and Hospitalization Characteristics of 30-Day SCD Readmissions

C. Patrick Carroll, MD, Carlton Haywood Jr, PhD, MA, and Sophie M. Lanzkron, MD, MHS
Departments of Psychiatry and Behavioral Sciences and Medicine, Johns Hopkins University
School of Medicine, Baltimore, Maryland

Abstract

Objectives—Sickle cell disease (SCD) is associated with a high level of emergency department and hospital utilization, as well as a high rate of hospital readmissions. At Johns Hopkins Hospital, as at other institutions, SCD accounts for a large proportion of readmissions. Our study examined patient and hospitalization factors involved in readmissions at Johns Hopkins Hospital.

Methods—Patients at the Johns Hopkins Sickle Cell Center for Adults with a readmission in fiscal year 2011 were compared with an age- and sex-matched sample of clinic patients for comorbidities, complications, and prior utilization. Hospitalizations that were followed by readmissions were compared with those that were not as to admitting service, length of stay, and average daily opioid dose.

Results—Patients with readmissions had more complications and comorbidities and much higher prior utilization than typical clinic patients, whereas hospitalizations that were followed by readmissions had a longer length of stay but similar opioid doses.

Conclusions—For patients with SCD with a high volume of hospital use, readmissions may be a natural consequence of a high-admission frequency associated with greater disease severity and higher comorbidity.

Keywords

sickle cell disease; healthcare utilization; readmissions

A large proportion of hospital admissions occur shortly after an index admission or initial admission that was followed by a readmission within 30 days. This suggests that the cause of the index admission may have been inadequately addressed when the individual was an inpatient or that outpatient care was not adequate to prevent relapse or progression. In recent years, hospital readmissions have been put forth as a marker of quality of care, although this has been controversial.^{1–10} Prospective remedies for this problem have been proposed at the level of hospitals and outpatient treatment, in particular in the transition to and from the outpatient and inpatient settings. Studies of these methods have yielded a number of

Correspondence to Dr C. Patrick Carroll, Department of Psychiatry and Behavioral Sciences, Johns Hopkins University School of Medicine, 600 N Wolfe St, Meyer 3-139, Baltimore, MD 21287. ccarroll1@jhmi.edu.

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successes and some paradoxical results in which the intervention appeared to increase rehospitalizations.^{4,11–17} Federal legislation has sought to incentivize reductions in readmissions by financially penalizing hospitals whose readmission rates are atypically high.¹⁸ The effects of this intervention remain to be seen.

Patients with sickle cell disease (SCD) are known to be particularly high-volume users of hospital services, although this high use rate is concentrated in a small subpopulation.^{19–22} In a report by the Agency for Healthcare Research and Quality, SCD was ranked as the condition with the highest readmission rate.²³ At Johns Hopkins Hospital, as at other institutions, patients with SCD contribute a disproportionate number of hospitalizations and readmissions. This has led to a focus on measures of quality of care during hospitalizations, with an eye to reducing hospitalizations and readmissions. One important starting point in this effort is to investigate individual patient characteristics associated with readmissions, as well as hospitalization characteristics that are predictive of readmission.

The present study was aimed at addressing this issue. Patients in the Johns Hopkins Hospital Sickle Cell Center for Adults (SCCA) who had a 30-day hospital readmission in fiscal year (FY) 2011 were identified and compared with active clinic patients who had no readmission on lifetime complications and comorbidities of SCD. Hospitalization characteristics among readmitted patients' index hospitalizations and hospitalizations that did not lead to a readmission were compared, including the type of service to which patients were admitted, primary diagnosis, length of stay, and average daily opioid dose.

Methods

Patient Factors

All of the patients at the SCCA are studied using a frequently updated clinical database. This database includes SCD-related parameters (eg, genotype) and lifetime complications and relevant comorbid conditions. A list of all of the patients who were part of the SCCA who had at least one hospital readmission in FY 2011 was obtained from hospital administrative records. Each of these patients ($n = 50$) was matched by age and sex with two control patients who were actively enrolled in the SCCA. Hospital identifiers were used to extract data from the clinical database. Variables extracted from the clinical database included genotype (coded as “SS” or “other”) and lifetime histories of avascular necrosis, acute chest syndrome (ACS), stroke, deep vein thrombosis, chronic kidney disease, asthma, hypertension, psychiatric illness, and substance use disorder. Hospital records were accessed to quantify total admissions in the prior year (2010) and the study year (2011) for each patient.

Each of these variables was screened for differences between cases and matched controls in bivariate comparisons using t tests or χ^2 tests as appropriate. Those that were statistically significant at the $\alpha = 0.05$ level were entered into a conditional logistic regression model, after which backward stepwise methods were used to refine the model to the smallest set of independent predictors of case-hood using an automated algorithm (stepAIC function of the Modern Applied Statistics with S package for R [R Foundation, Vienna, Austria]).²⁴ In the final analysis, prior year utilization was entered in the simplified model to determine what

predictive effects were mediated by relation to prior utilization. All of the statistical analyses were performed using the R statistical computing environment.

Hospitalization Factors

A list of all hospitalizations at Johns Hopkins Hospital for SCD was obtained from hospital administration databases for FY 2011. Scheduled admissions for high-dose chelation and bone marrow transplantation preparation were excluded, as were obstetric/gynecologic admissions and those admissions involving an intensive care unit stay.

Each admission was categorized as a single admission, an index admission, or a readmission based on the following criteria: a single admission was an admission with no other admission for the same patient within 30 days (either earlier or later). A readmission was an admission with at least one hospital admission for the same patient within 30 days. Index admissions were those admissions that were neither single nor readmissions—in other words, those that had a hospital admission for the same patient less than 30 days after but not 30 days before. Note that it was possible for a given index admission to be followed by multiple readmissions, so long as each readmission was within 30 days of the last. As such, one index admission may be the first in a long chain of readmissions if the admission frequency was sufficiently high.

Length of stay, the specialty service from which the patient was discharged, and whether the primary diagnosis was a vaso-occlusive crisis (VOC) were coded. Hospital medication administration records were obtained and used to quantify the total opioid doses received per day in morphine equivalents, using conversion tables from the American Pain Society.²⁵ Each of these variables was entered into a multivariable logistic regression model that predicted the difference between index and single admissions (ie, whether a given admission that was not itself a readmission was more likely to be followed by at least one readmission). The Johns Hopkins University institutional review board approved the study.

Results

Readmissions

There was a total of 133 readmissions (having excluded obstetric/gynecologic admissions, intensive care unit admissions, and scheduled admissions). Seven patients accounted for 52.6% of all readmissions. The top three readmitted patients accounted for 33.8% of all readmissions. The total number of admissions recorded for the period of interest was 435, meaning 30.6% of all admissions were readmissions. The active patient population in the SCCA is approximately 500, and as such it is reasonable to estimate that approximately 1.5% of the clinic population accounted for >50% of all readmissions.

Patient Factors

All of the complications and comorbidities examined were more prevalent in readmitted patients than in controls. There was a remarkably consistent pattern of complications being approximately twice as prevalent in the readmitted population (Table 1).

In the multivariable analyses (Table 2), the best model differentiating patients with readmissions from those without derived from backward stepwise selection included avascular necrosis of bone, ACS, chronic kidney disease, psychiatric diagnosis, and substance use disorder. When prior-year utilization was entered into the model, however, no other predictors were statistically significant, and the predictive capacity of the model increased.

Hospitalization Factors

Hospitalizations for index admissions were longer than single admissions, with readmissions having an intermediate length of stay (Table 3). Both index admissions and readmissions were more likely than others to have a VOC as their primary diagnosis. There also was a statistical trend suggesting a difference in type of service among the different admission categories. To differentiate index from single admissions in multivariable analyses, length of stay was a consistent predictor of being an index admission, and there was a modest trend suggesting that being admitted to a hospitalist service was more typical of index than single admissions (Table 4). The average daily dose of opioid did not differ among the admission types.

Discussion

Patients with readmissions presented with more lifetime complications and comorbidities, particularly ACS, psychiatric comorbidity, and avascular necrosis of bone, which is consistent with previous studies linking hospital utilization to greater comorbidity, measures of disease severity, and mortality.^{19,22,26,27} Effective treatment of SCD also reduces hospital utilization.^{28,29} As may be expected, the best statistical predictor of being a readmitted patient was greater prior utilization. Furthermore, a small minority of readmitted patients accounted for the majority of all readmissions, which is consonant with research that demonstrates that a small subpopulation of patients with SCD is responsible for a large proportion of hospital utilization.^{19,22,30}

At the level of individual admissions, the most consistent difference between index and single admissions was a greater length of stay. There appeared to be a greater chance for index admissions to be for VOC crisis, suggesting that there were different indications for hospitalization between these admission types and possibly that some of the single admissions were less emergent in nature; however, both index and single admissions were made predominately for VOC and the practical predictive capacity of this measure is likely to be minimal. In multivariable modeling, only length of stay differentiated index from single admissions.

A number of narrative explanations for readmissions have been suggested. One set, emphasizing hospital factors, has posited unduly short admissions and inadequate opioid dosing as possible causes.³¹ The possibility of opioid withdrawal resulting from inadequate dosing upon discharge also has been suggested to play a role.³¹ Another set of narratives emphasizes the complexity and severity of the patients' presenting problem, although this has been poorly studied in SCD.^{2,3,9}

Our study was limited by the use of historical diagnoses based on a clinical database, which itself is based principally upon charted diagnoses and ongoing updates by clinicians. This method does provide some strengths over cross-sectional measures, such as single-interview medical history taking or patient self-report. Temporally distant diagnoses are more likely to be captured. It is likely, however, that detection and entry of certain diagnostic entities less directly related to SCD itself, such as psychiatric illnesses, may be biased. It also is possible that patients who are seen more frequently (ie, high-volume users) may have a greater probability of having a diagnosis detected as a result of more frequent observation. The study also was limited in the scope of information available pertaining to in-hospital care beyond opioid dosing. There is little consensus on what aspects of in-hospital care may prevent readmission, however. The results of the study need replication using other methods, particularly methods that can provide more detail about in-hospital management.

The study also had significant strengths, particularly because it is among the first studies to describe both patient and hospitalization factors that may be involved in hospital readmissions for the adult subset of this important population. The methods allowed for a broad survey of clinically relevant and easily obtainable patient factors that may predict readmission and for preliminary testing of basic aspects of hospital management that speak to previous hypotheses regarding the causes of hospital readmissions in this patients with SCD.

Within its limits, this study supports patient and disease factors as being more salient in readmissions. The high concentration of readmissions within a small subpopulation of patients, the associations with greater medical and psychiatric comorbidity, and the strong relation of prior utilization to readmissions suggest that a small group of complex, ill, and high volume of use patients accounts for the majority of readmissions in this population. Although great detail regarding in-hospital management was not collected in this study, these data do not support that readmissions followed admissions that were rushed or which pain was systematically undertreated. In fact, index admissions were longer, and there were no differences in opioid dosing of a magnitude that was predictive. This conclusion must be tempered by concern for whether length of stay or opioid dosing was adequate, even if the same or greater. Given the complexities of managing VOC, however, decisions about adequacy of treatment are likely to be fraught with controversy and deserve study in their own right.

In patients with more sporadic hospitalization frequency, failures of in-hospital management or outpatient care may be a more salient cause, although this is likely to have a smaller impact than improvements in outpatient management of the high volume of use subpopulation. As such, interventions to reduce rehospitalizations in SCD may need to be targeted either to better outpatient management of the high volume of use subpopulation or the analysis and remediation of care problems for rehospitalizations that occur in sporadic users. Each of these approaches is likely to require different methods, and the target population will need to be defined at the outset.

Conclusions

Our results suggest that studying readmissions may require a more nuanced understanding of the phenomenon. In particular, for patients with a high volume of hospital use, readmissions may be a natural consequence of a high-admission frequency associated with greater disease severity and higher comorbidity. In this subpopulation, alterations in inpatient care may be of limited utility, whereas more comprehensive and higher intensity outpatient and day hospital services may be more effective. Certainly there is an acute need for more effective treatments that address the pathophysiology of the underlying disease.

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Key Points

- Adult patients with sickle cell disease with hospital readmissions had more lifetime complications and comorbidity.
- Hospitalizations that preceded readmission were longer, but opioid dosing was not different.
- The clearest associate of readmissions was prior-year utilization.

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Table 1

Characteristics of readmitted patients and clinic patient controls

	Control (n = 100)	Readmitted patients (n = 50)	P
SS genotype, %	64	74	0.218
Complications, %			
Avascular necrosis	25	52	0.001
Acute chest syndrome	50	84	<0.001
Stroke	9	18	0.110
Deep vein thrombosis	12	28	0.015
Chronic kidney disease	7	4	0.466
Comorbidities, %			
Asthma	15	36	0.003
Hypertension	17	28	0.117
Psychiatric diagnosis	25	48	0.005
Substance use disorder	18	36	0.015
Utilization			
Admissions 2010	0.48 (0.90)	3.42 (4.03)	<0.001
Admissions 2011	0.52 (1.00)	5.46 (4.16)	<0.001

Complications and comorbidities are recorded as lifetime prevalence as of the year studied. Utilization is recorded as mean hospital admissions per year (standard deviation). Statistical tests were χ^2 for proportional data or Student *t* tests for utilization data, as appropriate.

Table 2

Conditional logistic regression modeling differentiating readmitted patients from controls

	Full model		Final model		Utilization mediation	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Complications						
Avascular necrosis	6.49 (1.97–21.3)^A	0.002	6.89 (2.23–21.3)	<0.001	<i>2.39 (0.957–5.99)</i>	<i>0.062</i>
Acute chest syndrome	4.00 (0.918–17.4)	0.065	5.026 (1.24–20.4)	0.024	<i>2.57 (0.943–7.01)</i>	<i>0.065</i>
Stroke	1.45 (0.317–6.62)	0.632	—		—	
Deep vein thrombosis	1.47 (0.375–5.74)	0.582	—		—	
Chronic kidney disease	<i>0.0649 (0.003–1.41)</i>	<i>0.065</i>	<i>0.075 (0.004–1.54)</i>	<i>0.093</i>	0.310 (0.046–2.09)	0.310
Comorbidities						
Asthma	1.67 (0.496–5.63)	0.407	—		—	
Psychiatric history	<i>3.35 (0.975–11.5)</i>	<i>0.055</i>	<i>3.25 (0.996–10.6)</i>	<i>0.051</i>	1.79 (0.719–4.44)	0.211
Substance use disorder	2.33 (0.684–7.90)	0.176	2.59 (0.813–8.26)	0.107	1.35 (0.474–3.86)	0.573
Utilization						
Admissions 2010					1.94 (1.40–2.68)	<0.001
R ²	0.233		0.226		0.336	

Full model was fitted with all studied predictors. The final model was developed after an automated backward stepwise model selection procedure. The mediation by utilization model is the final model with prior year utilization added. *R*² figures are adjusted for multiple predictors. CI, confidence interval; OR, odds ratio.

^APls delineate between italic and bold values—usually indicate statistical significance, but they both can't mean that.

Table 3

Comparison of hospitalization characteristics between single and index admissions

	Index (n = 63)	Single admission (n = 239)	P
Length of stay, d	9.14 (7.51)	5.87 (7.46)	0.003
Service, %			0.104
General medicine	25.4	31.8	
Hematology	15.9	24.3	
Hospitalist	49.2	32.6	
Other	9.5	11.3	
Crisis diagnosis	85.7	77.8	0.168
Average daily opioid dose	617.7 (580.9)	524.4 (766.9)	0.315

Length of stay is reported in mean days (standard deviation). Average daily opioid dose is reported in mean milligrams morphine equivalents (standard deviation).

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Table 4

Logistic regression model distinguishing index from single admissions

	OR (95% CI)	P
Intercept	0.077 (0.033–0.163)	0.753
Length of stay	1.13 (1.07–1.20)	<0.001
Service		
Hematology	0.991 (0.372–2.56)	0.9212
Hospitalist	2.30 (1.10–5.04)	0.0284
General medicine	Ref	—
Other	0.990 (0.141–4.35)	0.9955

Outcome of interest is being an index admission; higher positive coefficients indicate greater odds of an admission being followed by a readmission. CI, confidence interval; OR, odds ratio.

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