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Predictors of Emergency Department Utilization and Hospitalization for Vaso-Occlusive Pain Crisis in Pediatric Patients with Sickle Cell Disease

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Abstract

Vaso-occlusive pain crisis (VOC) is the most common complication in pediatric patients with sickle cell disease seen in the emergency department (ED). The purpose of this study was to identify demographic and disease-related predictors of VOC in pediatric patients with SCD who present to the ED for pain. A retrospective chart review was conducted over a 6 year period. We examined differences in high ED utilization (>3 visits in any year) versus low ED utilization. Using multilevel regression models, we identified the strongest predictors of high ED utilization as older age, HbSS subtype, lower hemoglobin, and history of severe disease.

Keywords: Sickle cell; Pain; Emergency Department; Vaso-occlusive crises; Hospitalization; Utilization

Abbreviations: SCD: Sickle Cell Disease; VOC: Vaso-Occlusive Crisis; ED: Emergency Department; Hgb: hemoglobin; Hct: Hematocrit; MCV: Mean Corpuscle Volume; MCH: Mean Corpuscular Hemoglobin; MCHC: Mean Corpuscular Hemoglobin Concentration; ICD: International Classification Of Diseases; CDC: Centers For Disease Control And Prevention; AMA: Against Medical Advice

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Introduction

Sickle cell disease (SCD) affects 1 in every 365 Black/African American children in the United States [1]. Vaso-occlusive pain crises (VOC) are the most common complication of SCD [2]. Frequent VOC is associated with increased morbidity, mortality, and increased healthcare utilization [3,4]. While the majority of VOC are managed at home, some patients present to the emergency department (ED) for pain management [5,6]. Of the SCD subtypes (HbSS, SC, SB^0 thalassemia and SB^+), HbSS is the most common sickle cell subtype. Traditionally, HbSS has been associated with more severe disease and more frequent pain crises [4]. Despite well-identified disease processes, ED utilization for VOC is highly variable and poorly explained by SCD's single genetic variant.

The objective of this study was to identify demographic and disease-related predictors of ED utilization and hospitalization for VOC in pediatric patients with SCD [7]. We hypothesized that HbSS genotype, male, public insurance, visit during winter months, and worse blood laboratory values would be associated with high ED utilization [8,9] and predict total number of ED SCD visits and hospitalizations. We further examined whether ED length of stay, time till roomed, time till opioid analgesia, and total opioid dosage impacted healthcare utilization [10-12].

Research Methodology

Study design

Institutional IRB approval was obtained for an electronic health record-review from July 1, 2012 to October 25, 2018. Inclusion criteria: (1) SCD HbSS, SC, SB^0 thalassemia, or SB^+ thalassemia, (2) 5-19 years, and (3) admitted to pediatric ED for VOC only (ICD 9 and ICD 10 codes). An ED visit was included if the disposition was "discharge to home", "inpatient admission" or "inpatient observation". Patients who left against medical advice, eloped, or had non-VOC diagnosis were excluded (e.g., fever, acute chest syndrome, bone marrow failure).

Clinical investigation

Primary outcomes: ED visit was defined as registered in the pediatric ED. Hospitalized was defined as ED disposition of "inpatient admission" or "inpatient observation". Total number of ED visits and total number of hospitalizations were summed across the six year study period. Patients had High ED Utilization if they had ≥3 ED visits during any year.

Demographic and disease predictors: Demographics included age at visit, sex, race, SCD genotype, time of year (Winter, Spring, Summer, Fall) [13], and insurance. Body mass index [14], hemoglobin (Hgb), hematocrit (Hct), reticulocyte count (retic), mean corpuscle volume (MCV), mean corpuscular hemoglobin concentration (MCHC), and mean corpuscular hemoglobin (MCH) were extracted for each visit [15-17]. Severe SCD disease severity [18,19] was defined as 5 or more hospitalizations over the six year study period.

Exploratory variables

We examined whether ED length of stay (minutes), ED time until roomed (minutes), time till initial opioid administration, and total opioid dose (morphine equivalents/kilogram) were predictive of hospitalization for VOC [20,21].

Statistical analysis

Descriptive statistics, non-parametric one sample tests (males vs females; time of year), t-tests for continuous and chi-squared for categorical group differences were calculated in IBM SPSS 26 (IBM Corp). Linear and logistic regression models included mean values for predictors that varied across visits. Multilevel models for binary outcomes were specified using hierarchical linear models (HLM v.8) [22] to account for nesting of hospital visits within patients. 'Visit number' was included in all models, along with predictors that varied across visits: age, BMI, Hgb, Retic, MCV result, MCHC level, ED length of stay, ED time until roomed, time till initial opioid, and total opioid dose. Hct and MCH were highly correlated with other laboratory values (r's > .7) and were removed from regression and multilevel models. Genotype (1=SS/SB^0 thalassemia; 2=SC/SB+ thalassemia), sex, and insurance (0=Federal/self-pay; 1=private) were included as between-person predictors.

Results

Participant characteristics

Descriptive statistics for 248 patients across 1,363 ED visits are in **Table 1**. Patients were predominantly African American (99.6%).

Table 1 Demographics.

Variables	Low ED Utilization N=93	High ED Utilization N=158	Test statistic (*p*-value)	Total Sample	Range
	n (%)	n (%)		n (%)	
Male	44	88		132 (52.6)	
Female	49	70	1.65 (.20)	119 (47.4)	
Hb, SS/β^0 thalassemia	62	107		169 (67.3)	
Hb, SC/β^+ thalassemia	31	51	0.03 (.86)	82 (32.7)	
Private/Military insurance[a]	9	20		29 (11.6)	
Public/No insurance[a]	84	138	0.51 (0.48)	222 (88.4)	
	M (SD)	M (SD)		M (SD)	
Age, years	10.10 (4.03)	11.84 (3.76)	-4.91 (<0.001)	11.68 (3.81)	5-19
BMI	18.93 (5.41)	20.77 (5.76)	-3.09 (<0.01)	20.61 (5.74)	11-99
Hgb, g/dL	8.89 (1.75)	9.18 (1.66)	-1.75 (0.08)	9.16 (1.67)	4.1-16.8
Hematocrit	25.46 (4.64)	26.09 (4.74)	-1.32 (0.19)	26.03 (4.74)	13.1-45.1
Reticulocyte percent	8.09 (4.71)	7.87 (4.38)	0.44 (0.66)	7.89 (4.41)	0.1-18.1
MCHC level	34.87 (1.57)	35.26 (1.62)	-2.39 (0.02)	35.23 (1.62)	29.3-39.7
MCV	79.56 (10.66)	83.08 (10.50)	-3.31 (<0.01)	82.78 (10.55)	54.0-121.8
MCH	27.77 (4.13)	29.31 (4.05)	-3.76 (<0.001)	29.18 (4.08)	18.1-44.5
ED length of stay (min)	205.52 (80.80)	229.91 (86.01)	-3.05 (<0.01)	227.65 (85.81)	16-875
Time to first opioid (min)	61.89 (39.95)	62.99 (40.18)	-0.26 (0.79)	62.90 (40.14)	5-319
ED morphine equivalency dosage	.11 (.10)	0.13 (0.10)	-2.42 (0.02)	0.13 (0.10)	0-0.61
Total ED visits per patient[b]	2.19 (1.13)	13.77 (13.66)	-8.15 (<0.001)	9.48 (12.21)	1-94
Total hospitalizations per patient[b]	1.11 (1.08)	5.65 (6.61)	-6.56 (<0.001)	3.96 (5.72)	0-39

Notes: [a]Insurance payer was collected for first ED visit for each patient.
[b]Total ED and total hospitalizations per patient are summed over the six year study period.

Table 2 Multi-level logistic regression model predicting hospitalization (Yes/No).

Variables	*b* (*SE*)	OR (95% CI)	p-value
Genotype[a]	0.08 (0.45)	1.09 (0.45, 2.64)	0.86
Insurance[a]	0.48 (0.49)	1.62 (0.61, 4.30)	0.33
Visit number	-0.02 (0.01)	0.98 (0.97, 0.99)	0.03
Age	-0.00 (0.17)	1.00 (0.72, 1.39)	0.99
BMI	0.86 (0.19)	2.36 (1.62, 3.43)	<0.001
Hgb, g/dL	-0.46 (0.17)	0.63 (0.46, 0.88)	<0.01
Reticulocyte Percent	0.11 (0.15)	1.11 (0.83, 1.51)	0.47
MCHC Level	0.04 (0.11)	1.04 (0.84, 1.28)	0.74
MCV Result	0.06 (0.13)	1.06 (0.81, 1.37)	00.68
ED Length of Stay (min)	-0.49 (0.16)	0.61 (0.45, 0.84)	<0.01
ED time till roomed (min)	-0.15 (0.09)	0.86 (0.72, 1.02)	0.09
ED Time Till Opioid (min)	0.29 (0.13)	1.34 (1.05, 1.71)	0.02
ED Morphine equivalency	1.80 (0.16)	6.03 (4.41, 8.26)	<0.001
[a]Categorical variables			

Mean age at first ED visit was 9.7 (SD=3.9). Thirty patients (12.1%) had one ED visit, 100 patients (40.3%) had two to five visits, and 118 patients (47.6%) had six or more visits. All patients had normal BMI, except for one visit reflecting obesity. ED visits were evenly distributed across time of year (Chi-Squared=1.23, p=0.75). A subset of 61 patients (24.6%) were classified as severe SCD disease severity.

High versus low ED utilization

A substantial subset (62.9%) of patients classified as having High ED Utilization. Patients with High ED Utilization were typically older, had severe SCD disease, had lower Hgb levels, had lower MCV, and had more hospitalizations than Low ED Utilization counterparts (p's <0.05; **Table 1**).

Predicting total number of ED visits and hospitalizations

SCD genotype, demographic (age at visit, sex), BMI, and laboratory values (Hgb, retic, MCV, MCHC) at ED admission were not significantly associated with total number of ED visits or total number of hospitalizations in linear regression models (all p's >0.05).

Predicting High ED Utilization

A logistic regression model revealed that age, BMI, and laboratory value were not significantly associated with High ED utilization (all p's >0.05).

Predicting hospitalization

The odds of being hospitalized decreased as patients' number of visits increased (**Table 2**). Higher BMI and lower Hgb level were associated with increased likelihood of hospitalization. No laboratory values were associated with hospitalization. Specific to the ED visit, longer ED visits were associated with decreased odds of hospitalization. However, longer time until receiving first opioid and higher total morphine equivalency dosage was associated with increased likelihood of hospitalization for VOC.

Discussion

Compared to their Low ED Utilization counterparts, patients with High ED Utilization (62.9%) tended to be older, have severe SCD disease, have lower Hgb levels, and have lower MCV result. Early identification and recognition of these higher risk patients in the outpatient setting may allow for earlier healthcare intervention and decreased hospital utilization [23,24]. Despite examining a range of demographic and medical laboratory predictors we did not identify any significant predictors of total ED visits, total hospitalizations, or High ED Utilization in regression analyses. These null findings are consistent with previous literature and suggest that the frequency of SCD VOC complications is highly individual.

Lower Hgb level, requiring more opioid medications, and requiring a longer ED length of stay are reflective of the clinical picture leading to hospitalization. At our institution, time to initial opioid administration fell in line with the current National Lung Blood and Heart Institute (NHLBI) recommendations for opioid administration within 1 hour. However, initial opioid morphine equivalency dosage was frequently low for weight status, and may have been inadequate to treat VOC, contributing to a higher hospitalization rate.

Limitations

In this clinical setting, there is risk that patient diagnoses were misclassified, coding differences occurred between ICD 9 and ICD 10 codes, and changes in practice occurred after 2014 NHLBI recommendations published during this study period. While our institution is the only pediatric hospital in the state, it is likely not all VOC ED visits were captured due to patients being seen at their local ED and 16 years and older occasionally alternating care between the pediatric and adult ED.

Conclusion

Based on the current study and larger literature, the strongest predictors of high ED utilization in pediatric patients with SCD include older age, HbSS subtype, lower Hgb level, and prior history of complication (i.e., severe SCD disease). Additional studies are critically needed to identify novel predictors of high ED utilization and test standardized interventions in both the outpatient and ED setting.

Conflict of Interest

Authors declare no conflict of interest.

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References

1 https://www.cdc.gov/ncbddd/sicklecell/data.html.

2 Salman ZA, Hassan MK (2015) Hospitalization events among children and adolescents with sickle cell disease in Basra, Iraq. Anemia.

3 Hardy SJ, Bills SE, Wise SM, Hardy KK (2018) Cognitive abilities moderate the effect of disease severity on health-related quality of life in pediatric sickle cell disease. J Pediat Psychol 43: 882-894.

4 Aisiku IP, Smith WR, McClish DK, Levenson JL, Penberthy LT, et al. (2009) Comparisons of high versus low emergency department utilizers in sickle cell disease. Ann Emerg Med 53: 587-593.

5 Carroll CP, Haywood JC, Fagan P, Lanzkron S (2009) The course and correlates of high hospital utilization in sickle cell disease: Evidence from a large, urban Medicaid managed care organization. Amer J Hematol 84: 666-670.

6 Jacob SA, Mueller EL, Cochrane AR, Carroll AE, Bennett JWE (2020) Variation in hospital admission of sickle cell patients from the emergency department using the Pediatric Health Information System. Pediat Blood Cancer 67: e28067.

7 Mvundura M, Amendah D, Kavanagh PL, Sprinz PG, Grosse SD (2009) Health care utilization and expenditures for privately and publicly insured children with sickle cell disease in the United States. Pediat Blood Cancer 53: 642-646.

8 Lanzkron S, Carroll CP, Haywood JC (2010) The burden of emergency department use for sickle cell disease: An analysis of the national emergency department sample database. Amer J Hematol 85: 797.

9 Darbari DS, Onyekwere O, Nouraie M, Minniti CP, Luchtman-Jones L, et al. (2012) Markers of severe vaso-occlusive painful episode frequency in children and adolescents with sickle cell anemia. J Pediat 160: 286-290.

10 Payne J, Aban I, Hilliard LM, Madison J, Bemrich-Stolz C, et al. (2018) Impact of early analgesia on hospitalization outcomes for sickle cell pain crisis. Pediat Blood Cancer 65: e27420.

11 Brandow AM, Nimmer M, Simmons T, Charles Casper T, Cook LJ, et al. (2016) Impact of emergency department care on outcomes of acute pain events in children with sickle cell disease. Amer J Hematol 91: 1175-1180.

12 Lin SM, Strouse JJ, Whiteman LN, Anders J, Stewart RW (2016) Improving quality of care for sickle cell patients in the pediatric emergency department. Pediat Emerg Care 32: 14-16.

13 Zivot A, Apollonsky N, Gracely E, Raybagkar D (2017) Body mass index and the association with vaso-occlusive crises in pediatric sickle cell disease. J Pediat Hematol Oncol 39: 314-317.

14 https://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html.

15 Billett HH (1990) Hemoglobin and hematocrit. In Clinical Methods: The History, Physical, and Laboratory Examinations. 3rd Edition. Butterworths.

16 Bessman JD (1990) Reticulocytes. In Clinical Methods: The History, Physical, and Laboratory Examinations. (3rd edn). Butterworths, UK.

17 Walker HK, Hall WD, Hurst JW (1990) Peripheral Blood Smear--Clinical Methods: The History, Physical, and Laboratory Examinations. Butterworths.

18 Panepinto JA, Torres S, Bendo CB, McCavit TL, Dinu B, et al. (2013) PedsQL™ sickle cell disease module: feasibility, reliability, and validity. Pediat Blood Cancer 60: 1338-1344.

19 Loeffler P, Mueller T, Kutlar A, Gibson R, Sturgis L, et al. (2015) Frequency of Emergency Department Visits for Sickle Cell Disease Vaso-Occlusive Crisis and Its Contribution to Hospital Admission Rates.

20 Kavanagh PL, Sprinz PG, Wolfgang TL, Killius K, Champigny M, et al. (2015) Improving the management of vaso-occlusive episodes in the pediatric emergency department. Pediat 136: e1016-e1025.

21 Yawn BP, Buchanan GR, Afenyi-Annan AN, Ballas SK, Hassell KL, et al. (2014) Management of sickle cell disease: summary of the 2014 evidence-based report by expert panel members. JAMA 312: 1033-1048.

22 Raudenbush SW (2004) HLM 6: Hierarchical linear and non-linear modeling. Scientific Software International.

23 Brandow AM, Weisman SJ, Panepinto JA (2011) The impact of a multidisciplinary pain management model on sickle cell disease pain hospitalizations. Pediat Blood Cancer 56: 789-793.

24 Akenroye AT, Thurm CW, Neuman MI, Alpern ER, Srivastava G, et al. (2014) Prevalence and predictors of return visits to pediatric emergency departments. J Hosp Med 9: 779-787.