Research Article

Epidemiology and Perioperative Complications in Patients With Sickle Cell Disease After Orthopaedic Surgery: 26 Years' Experience at a Major Academic Center

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Abstract

Introduction: Surgical management of patients with sickle cell disease (SCD) poses a unique challenge to orthopaedic surgeons due to increased operative and perioperative risk. Studies evaluating perioperative complications among patients with SCD undergoing orthopaedic surgery have been limited. We sought to review the clinical characteristics and perioperative complications in our patients with SCD who required orthopaedic surgery.
Methods: Our institution has one of the largest sickle cell centers in the Northeastern United States. We performed a retrospective chart review of all patients referred to the Orthopaedic Surgery Department between 1990 and 2016 and analyzed the demographics, comorbidities, surgical intervention, and perioperative complications.
Results: In total, 96 orthopaedic surgeries were surveyed across 26 years performed at our institution. The majority of the patients with SCD were African American (90.3%) and women (60.4%). The most common surgical intervention was for hip osteonecrosis. Only 11.5% of the patients (11 of 96) experienced a perioperative complication, with the vasoocclusive event being the most common (7 patients; 64%).
Discussion: These data suggest that orthopaedic surgery for a patient with SCD is safe but does require careful multidisciplinary consultation including hematology and anesthesia to medically optimize the patient before surgical intervention.

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Sickle cell disease (SCD), first described in 1910 by James B. Herrick, is a clinically heterogeneous genetic hemoglobinopathy characterized by polymerization of the hemoglobin (Hb) tetramer in hypoxic conditions with the subsequent formation of an inflexible crescent-shaped "sickle" erythrocyte.[1] This structural deformity and the resultant abnormal interactions between sickle erythrocytes, leukocytes, platelets, and the vascular endothelium lead to increased blood viscosity, impaired microvascular blood flow, tissue ischemia, reperfusion injury, and promotion of inflammation, thrombosis, and oxidant stress.[2] This diffuse vasculopathy underlies many of the complications of SCD and currently remains without a specific therapy.

SCD affects nearly 100,000 individuals living in the United States and is diagnosed in 275,000 births worldwide annually.[3,4] Diggs, Pulliam, and King were the first to describe the skeletal manifestations of SCD, which include musculoskeletal pain, dactylitis, osteomyelitis, and septic arthritis.[5,6] These orthopaedic complications and others are major contributors to the overall morbidity of SCD and often require surgical intervention.[6,7] The most common musculoskeletal manifestation of SCD, with an incidence of around 10%, is osteonecrosis, which is defined as the massive necrosis of bone and bone marrow occurring in the absence of other bony abnormalities.[7]

Surgical intervention in patients with SCD poses unique challenges because of the high risks of intraoperative and postoperative complications. These include acute blood loss and worsening anemia, transfusion reactions exacerbated by the increased rate of alloimmunization, and vasoocclusive events.[8,9] One particularly serious type of vasoocclusive event, the acute chest syndrome, occurs in 0.4% to 10% of patients with SCD undergoing surgery, with a reported mortality between 25% and 50% in some series.[8,10,11] Additionally, hip and knee arthroplasty procedures place the already hypercoagulable SCD patient at increased thrombotic risk. Recent studies suggest that up to 67% of patients with SCD experience serious perioperative complications from orthopaedic procedures; those undergoing total hip arthroplasty (THA) are at the highest risk.[9]

Several risk factors for perioperative complications in patients with SCD have been identified. Vichinsky et al[8] determined that patients with preexisting pulmonary disease and those undergoing higher risk surgeries were at increased risk for acute chest syndrome. Haberkern et al[12] noted that the risk of SCD complications correlated directly with the number of prior SCD-related hospitalizations and a lack of preoperative transfusion. Despite the increased perioperative risks, a strategy that includes preoperative transfusion, strict intraoperative monitoring, and minimized use of tourniquets and contrast medium decrease these risks, making surgical intervention a safer option for those with SCD, but their utilization is not universally followed.[6,9,12-14] Given the prevalence of SCD and the increased number of orthopaedic treatment options for these patients, the goal of the present study was to describe the epidemiology and perioperative management and complications of these patients at our tertiary referral orthopaedic department for surgery. Furthermore, we will also discuss management strategies at our hospital for the reduction of orthopaedic surgery-related perioperative complications.

Methods

We performed a retrospective chart review of all patients referred to the Orthopaedic Surgery Department between 1990 and 2016. Of note, our hospital has the largest sickle cell center in our geographic region. Adults ≥18 years of age who had International Classification of Disease-9/10 (ICD-9/10) codes for both a sickle cell hemoglobinopathy and any orthopaedic surgical intervention necessitating general anesthesia were included in the study. Patients <18 years of age were excluded from the study because of the small patient population at our hospital (~2 cases) and because of the varying presentation of SCD in the pediatric versus adult population. Patients were identified using our institution's Clinical Data Warehouse (CDW). The CDW is a relational database that collects data from our institution's major electronic data systems, including inpatient, outpatient, emergency department, operating room, and billing services. Information is collected nightly or weekly from the various source systems at the hospital and community health centers and is integrated into the CDW through an Exact, Transform, Load system using Informatica's PowerCenter application. Analysts use structured query language to gather data from the CDW.

ICD-9 and ICD-10 diagnosis codes from the billing records were used to identify all patients with SCD with and without vasoocclusive crises who received surgery within our orthopaedic surgery department. The ICD-9 codes included 282.6, 282.60, 282.61, 282.62, 282.63, 282.64, 282.68, 282.69, whereas the ICD-10 codes included D57.0, D57.00, D57.01, D57.02, D57.1, D57.2, D57.20, D57.21, D57.211, D57.212, D57.219, D57.3, D57.4, D57.40, D57.41, D57.411, D57.412, D57.419, D57.8, D57.80, D57.81, D57.811, D57.812, D57.819. We performed a retrospective clinical chart review of all surgical cases. Demographic information including age, sex, race/ethnicity, and body mass index were obtained. We included SCD-related medical history including Hb genotype, history of vasoocclusive events, acute chest syndrome (ACD), priapism, pulmonary hypertension, dactylitis, prior stroke, and lower extremity ulcers. Additionally, we collected non-SCD medical history (hypertension, diabetes mellitus, obstructive sleep apnea, venous thromboembolism [defined as deep vein thrombosis, pulmonary thrombosis, or pulmonary embolism], and renal dysfunction). We included Emergency Department visits in the prior year and the diagnosis associated with these visits and prior surgical history. For the index orthopaedic

surgery, we obtained the surgical indication, site, American Society of Anesthesiologists (ASA) classification, preoperative consults/testing obtained, perioperative transfusions performed, perioperative complications, length of inpatient hospitalization, discharge location (home, rehabilitation facility, etc.), and if a readmission occurred, the reason for readmission.

The descriptive analysis was performed using the R 3.3.2 statistical software. Continuous variables were reported as means and standard deviations, whereas categorical variables were reported as numbers and percentages. Categorical data were analyzed by chi square analysis.

Table 1

Demographic Characteristics of Patients With Sickle Cell Disease Referred for Orthopaedic Surgery 1994-2016

Variable	Mean (SD, range) or Frequency (%)
Age (n = 96)	37.5 (15.8, 18-81)
Sex	
Male	38 (39.6%)
Female	58 (60.4%)
Race/ethnicity (n = 96)	
Black or African American	84 (90.3%)
Hispanic or Latino	7 (7.5%)
White	2 (2.2%)
BMI	28.2 (7.1)
SCD genotype (n = 95)	
Hb SS	51 (53.1%)
Hb SC	41 (42.7%)
Hb Sβ+ thalassemia	3 (3.1%)

BMI = body mass index, Hb = hemoglobin, SCD = sickle cell disease

Results

A total of 96 orthopaedic surgeries were identified at our institution. Their demographic and clinical data are presented in Tables 1 and 2. Fifty-eight (60.4%) individuals were women and 90.3% were African American. The mean age at the time of surgery was 37.5 ± 15.8 years (range, 18 to 81 years) and the average body mass index was 28.2 ± 7.1. Most patients had either Hb SS (53.1%) or Hb SC (42.7%) disease.

The use of pain medication was common with 74% prescribed chronic opioids, 53.1% receiving nonsteroidal anti-inflammatory agents, and 33.9% taking acetaminophen. The SCD-specific medications, folic acid and hydroxyurea, were used by 57.3% and 49% respectively. One-third of the cohort (33.3%) had a history of hypertension, and 40.6% had undergone a cholecystectomy. Nearly two-thirds (61.5%) had a prior history of vasoocclusive events and 43.8% had a history of ACD. The median number of emergency department visits in the year before surgery was 1, and the most common reason was for a vaso-occlusive event.

A list of surgical indications is provided in Table 3 and Table 4. Osteonecrosis was the surgical indication in 52.1% of the cases, most commonly involving the hip (44.8% of the surgeries). Twenty-nine of the 43 (30.2%) hip surgeries were a THA, and 14 (14.6%) were a bone marrow aspirate concentrate. Of the other elective procedures, spinal surgery was the next most common site (11.5%), followed by shoulder (9.4%), knee (5.2%), and hand (4.2%) surgery. Orthopaedic surgery for trauma was performed in 22 of the 96 cases (22.9%).

Most of those undergoing surgery had an ASA classification of 3 (65.6%) or 2 (27.1%; Table 5). Forty-six cases (47.9%) were evaluated preoperatively by hematology and 35.4% by anesthesia. Preoperatively, 58.3% received no transfusion, 31.3% received a simple transfusion, and 10.4% had an exchange transfusion. Thirteen patients (13.5%) were transfused intraoperatively, and 28.1% received a simple transfusion postoperatively. Eleven patients (11.5%) had a postoperative complication, with a vasoocclusive event occurring in seven patients. The length of stay following surgery averaged 5.4 days (± 4.5 days; range 0 to 26), and 71.9% were discharged directly home. Six patients (6.5%) were readmitted within 30 days postoperatively (Table 5). We evaluated the use of preoperative hematology consultation and transfusion in the 11 patients who had perioperative complications (Table 6). Six of them (55%) had either a transfusion, a hematology consult, or both. Three (27%) had neither a hematology consultation nor a transfusion preoperatively.

The demographic data pertaining to those patients who experienced a postoperative complication are detailed in Table 7. Two of the 11 patients had the HbSC genotype, whereas the remaining nine patients were HbSS. Further, all patients had preoperative comorbidities that included either a vasoocclusive crisis or ACD. Patients were predominately classified as ASA 3 (81.8%, 9 of 11), with the remaining two patients having an ASA score of 2. In addition, six patients (54.5%) underwent an operation on the hip, with osteonecrosis being the indication for each of these procedures.

Table 2

Clinical Characteristics of Patients With Sickle Cell Disease Undergoing Orthopaedic Surgery

Variable	Frequency (%)
SCD-related previous medical history	
Vasoocclusive crisis	59 (61.5)
Acute chest syndrome	42 (43.8)
Priapism	14 (14.6)
Pulmonary hypertension	10 (10.4)
Prior stroke	12 (12.5)
Lower extremity ulcers	1 (1.0)
Other medical history	
Hypertension	32 (33.3)
Diabetes mellitus	9 (9.4)
Chronic kidney disease	19 (19.8)
Venous thromboembolism	
Deep vein thrombosis	9 (9.4)
Pulmonary embolism	17 (17.7)
Obstructive sleep apnea	9 (9.4)
Prior surgical history	
Cholecystectomy	39 (40.6)
Splenectomy	9 (9.4)
Adenotonsillectomy	3 (3.1)
Medications	
Chronic opioids	71 (74.0)
Nonopioid pain medication	
NSAIDs	51 (53.1)
Acetaminophen	37 (33.9)
Hydroxyurea	47 (49.0)
Folic acid	55 (57.3)
Smoking (n = 91)	
Previously smoked/currently smoke	71 (78.0)
Never smoked	20 (22.0)

Most common reasons for ER visits in the past yr (n = 341)	No. of times indicated
Vaso-occlusive event	266 (78.0%)
Joint pain	39 (11.4%)
Other	36 (10.56%)

SCD = sickle cell disease

Table 3

Documented Reason for Surgical Intervention

Variable	Frequency (%)
Osteonecrosis	50 (52.1)
Trauma	19 (19.8)
Degenerative pathology	9 (9.4)
Infection	3 (3.1)
Other	15 (15.6)

Osteonecrosis was also the reason for surgery in 8 of the 11 patients who had a postoperative complication.

Discussion

The current study expands our knowledge on the epidemiology and perioperative compilations of patients with SCD after orthopaedic surgery by including patients from all orthopaedic subspecialties (hand, spine, shoulder, and knee) undergoing both elective and emergent procedures over a 26-year period from one single institution. In this study, we retrospectively reviewed all 96 orthopaedic surgeries performed on patients with SCD between 1990 and 2016 and report an overall perioperative complication rate of 11.5%. In our patients with SCD, perioperative vasoocclusive events were most common, accounting for 7 of the 13 complications (7.3%). Additionally, one patient had ACD (1%), one had a venous thromboembolism (1%), and one had a transfusion reaction (1%). Of those patients who experienced a postoperative complication, all had significant preoperative comorbidities that included either a previous vasoocclusive crisis or ACD. These patients, as hypothesized, were generally sicker (81.8% had an ASA score of 3) compared with patients who did not experience a complication event postoperatively. Postoperative complications were also more common in procedures that were technically more demanding and had longer operative time, in accordance with the literature.[8] Specifically, four of the 11 patients had undergone a total hip arthroplasty. Yet, the complication rate for THA in our patient population (13.8%, 4 of 29 procedures) is still drastically less than what has been reported in other series.[9] As such, we hypothesize that the lower rate of complications seen in our study compared with the literature may relate to the enhanced preoperative management strategies

including consultation with hematology and the use of transfusion. These data may suggest that successful integration of both services will maximize the chances of a positive surgical outcome.

Bone involvement is the most common clinical presentation of SCD both in the acute setting (painful vasoocclusive crises) and in chronic progressive manifestations (osteonecrosis).[15] Orthopaedic complications are common and while typically not life threatening, contribute to the significant morbidity of SCD. Specifically, de Gheldere et al[16] retrospectively reviewed patients with sickle-cell disease between 1975 and 2004 and found that 79 of 325 patients had orthopaedic complications related to their disease. In contrast to our study, where two of the 11 postoperative complications occurred in patients with the HbSC genotype, complications were observed only in patients with the HbSS genotype. The most common complications were diaphyseal necrosis in 45 patients (16%), bone or joint infection in 15 individuals (5%), and epiphyseal osteonecrosis in 12 others (4%). Other studies have demonstrated osteonecrosis in up to 50% of patients with the HbSS genotype,[17] affecting the hip in approximately 10% of patients.[18,19]

It is well understood that surgical interventions in patients with SCD result in increased perioperative risks. In a large multicenter prospective study, Vichinsky et al[8] compared whether conservative (increasing the Hb concentration to 10 g/dL by simple transfusion) or aggressive (decreasing the percentage of HbS to less than 30% by exchange transfusion) regimens led to decreased perioperative risks. They found that regardless of transfusion strategy, serious adverse events occurred in 30% to 35% of the patients, with 10% of patients experiencing ACD. This is markedly higher than in the general population where the risk for serious pulmonary events following surgery is normally less than 1% (excluding atelectasis).[20,21] Whereas aggressive transfusion may not be necessary, a study from Howard et al[22] demonstrated that preoperative transfusions to increase the Hb concentration to 10 g/dL should be employed for most surgeries on SCD patients, particularly if they require general anesthesia. This study has since formed the framework for standardized preoperative transfusions to maintain the Hb above 10 g/dL in patients with SCD undergoing orthopaedic procedures, which has been implemented within our institution.[22]

Yet, despite how common SCD-related orthopaedic complications are, few studies have specifically addressed the perioperative risk in patients presenting for orthopaedic surgery. Vichinsky et al[9], in a follow-up prospective study, evaluated 138 elective orthopaedic surgeries on 118 patients with SCD and found that complications occurred in more than two-thirds of all procedures. Excessive intraoperative blood loss (defined as more than 10% of total blood volume) occurred in 44%, while ACD and vasoocclusive events occurred in 17%. Most procedures were total hip arthroplasties (52, 38%), which had the highest complication rate (96%). Excessive blood loss occurred in 71% of patients, and 19% had a vasoocclusive event postoperatively. Of the 22 patients who underwent hip coring (decompression), 14% had ACD and 18% had a vasoocclusive event.[9] Contrary to the above findings, our study found that only 5 of 43 patients (11.6%) experienced postoperative complications after orthopaedic hip procedures. The differences may relate to the perioperative multidisciplinary management or surgical technique between our institution and the above study.

Similar to our study and findings, Hernigou et al[23] retrospectively reviewed 312 hip arthroplasties performed at their institution and observed postoperative complications in only 27%, suggesting a lower risk than what was previously

Table 4

Type of Surgery Based on Region and Specialty

Variable	Frequency (%)
Shoulder surgery	9 (9.4)
BMAC	3 (3.1)
Arthroscopy	1 (1.0)
Arthroplasty (Hemi, TSA, RSA)	5 (5.2)
Hip surgery	43 (44.8)
Core decompression	1 (1.0)
BMAC	14 (14.6)
Arthroscopy	1 (1.0)
THA	29 (30.2)
Knee surgery	5 (5.2)
Arthroscopy	2 (2.1)
TKA	3 (3.1)
Spine surgery	12 (11.5)
Hand surgery	4 (4.2)
Trauma surgery	22 (22.9)

BMAC = bone marrow aspirate concentrate, RSA = reverse total shoulder arthroplasty, THA = total hip arthroplasty, TKA = total knee arthroplasty, TSA = total shoulder arthroplasty

Table 5

Overview of Operative Management and Complications

Variable	Frequency (%)
ASA classification (n = 93)	
1	0 (0)
2	26 (27.1)
3	63 (65.6)
4	4 (4.2)
5	0 (0)
Preoperative testing/consults (119 total consults)	
Hematology	46 (47.9)
Anesthesia	34 (35.4)
Internal medicine	33 (34.4)
Cardiology	0 (0)
Rheumatology	3 (3.1)
Renal	2 (2.1)
Infectious disease	1 (1.0)
Psychiatric	0 (0)
Preoperative transfusion?	
No transfusion	56 (58.3)
Simple transfusion	30 (31.3)
Exchange transfusion	10 (10.4)
Intraoperative blood transfusion?	
Yes	13 (13.5)
No	83 (86.5)
Intraoperative complication	
Yes[a]	5 (5.4)
No	88 (94.6)
Postoperative complications	13 (13.5)
Pain crisis	7 (7.3)
Acute chest syndrome	1 (1.0)
Transfusion reaction	1 (1.0)
PE/DVT	1 (1.0)
CHF	0 (0)
Leg sores/ulcers	0 (0)
Infection	0 (0)
Other[b]	3 (3.1)
Postoperative transfusion?	
No transfusion	69 (71.9)
Simple transfusion	27 (28.1)
Exchange transfusion	0 (0)
Length of inpatient stay[c]	5.4 (4.5; 0-26)
Discharge	
Home	69 (71.9)
Rehabilitation	25 (26.0)
Readmitted?	
Yes[d]	6 (6.25)
No	88 (91.7)

ASA = American Society of Anesthesiologists, CHF = congestive heart failure, PE/DVT = pulmonary embolism/deep vein thrombosis, VOC = vaso-occlusive crisis

[a] Proximal femur fracture with cerclage wiring (×3), guidewire broke in femur (×2)

[b] Acute kidney injury (AKI) (×2), hyperkalemia, bleeding due to supratherapeutic international normalized ratio and AKI on chronic kidney disease in one patient

[c] Reported in terms of mean (SD, range)

[d] (1) hip pain and serosanguinous discharge, anemia, AKI; (2) Vaso-occlusive crisis (VOC); (3) Pulmonary embolism; (4) Acute interstitial nephritis secondary to levofloxacin; (5) VOC; (6) acute chest syndrome, VOC

observed. Most commonly, they identified major (2.9%) and minor (19%) transfusion reactions. In this cohort, there were only four (1.3%) cases of ACD and they reported an average blood loss of 950 mL. They attributed the reduction in SCD-related complications to the multidisciplinary management strategies employed by their medical and surgical teams.[23] Further, to assess long-term outcomes, Ilyas and Moreau[24] followed 18 consecutive HbSS patients after simultaneous bilateral THA. The average time of follow-up was 5.7 years. In total, only two of the nine complications documented were vasoocclusive events that were in the immediate postoperative period. The other complications included one superficial and one deep infection and five surgical complications (eg, acetabular cup revision due to instability).

In total, our patient cohort consisted of 58 women (60.4%) and 38 men (39.6%), with 84 patients (90.3%) of black/African American race and 7 patients (7.5%) of Hispanic/Latino ethnicity. Of these patients, 53 (53.1%) had the HbSS genotype and 41 (42.7%) had the HbSC genotype. These data largely correspond to patient demographics reported elsewhere, which show that SCD affects men and women roughly equally (47.3% versus 52.6%, respectively), but with a predilection for African Americans (90% of all SCD patients) and Hispanics (4.0%).[25] Further, in examining the clinical characteristics of our patients with SCD undergoing orthopaedic surgery, 59 patients (61.5%) and 42 patients (43.8%) had experienced a previous vasoocclusive event or an ACD, respectively. The next most common SCD-related comorbidity included priapism (14, 14.6%) followed by prior stroke (12, 12.5%). In comparison to the California Office of Statewide Planning and Development discharge database

Table 6

Summary of Complications, Preoperative Consults and Transfusion Status

Complication Type	Hematology Consult	Preoperative Transfusion	Intraoperative Transfusion	Postoperative Transfusion	Any Transfusion
Pain crisis, bleeding due to supratherapeutic INR, AKI on CKD	Yes	No	No	Yes	Yes
Transfusion reaction	No	No	No	Yes	Yes
Pain crisis	No	No	No	No	No
Pain crisis	No	No	No	Yes	Yes
ACS, pain crisis	Yes	No	Yes	No	Yes
AKI, hyperkalemia	Yes	Yes	No	Yes	Yes
AKI	Yes	Yes	Yes	No	Yes
Pain crisis	Yes	Yes	No	No	Yes
Pain crisis	No	Yes	No	Yes	Yes
Pain crisis	No	Yes	No	No	Yes
PE/DVT	Yes	Yes	No	Yes	Yes

ACS = acute chest syndrome, AKI = acute kidney injury, CKD = chronic kidney disease, INR = international normalized ratio, PE/DVT = pulmonary embolism/deep vein thrombosis

from 1991 to 2013, which serves as a benchmark for the United States SCD population, the percentage of all patients with SCD who experienced an ACD was 28.4%, but this number rose to 44.0% when solely examining patients with SCD who had osteonecrosis of the femoral head; this latter subset of patients better aligns with our surgical cohort and closely matches the reported value in our patient population.[25] In addition, 33.3% of our patients had a history of hypertension, 10.4% had pulmonary hypertension, 9.4% had diabetes mellitus, and 19.8% had chronic kidney disease. This compares to literature reports, which indicate that the relative prevalence of cardiovascular disease, pulmonary disease, diabetes, and renal disease are roughly 43%, 19%, 16%, and 13%, respectively, among SCD patients.[26] This suggests that our population predominantly mimics the general SCD population and limits the notion that our lower complication rate is a product of a healthier subset of patients. Further, in congruence with prior reports, osteonecrosis, particularly of the hip, was the most common indication for surgery. Yet, our finding that osteonecrosis of the hip affected 44.8% of our patients was higher than the 22% of patients who experienced osteonecrosis of the hip according to the California discharge database.[25]

Our study has several limitations. As it was retrospective, we were unable to assess the exact amount of intraoperative blood loss, which may have led to an underestimation of the complication rate. However, in the senior author's experience, it is very difficult to estimate the exact amount of blood loss intraoperatively during an orthopaedic procedure. Additionally, the inclusion of both low- (elective hand) and high-risk (emergent trauma or THA) surgeries in this study may have impacted the findings and our report of complications. Our relatively small sample size limited the statistical power to determine whether certain factors increased postoperative risk in these patients.

Ultimately, based upon the literature and our clinical experience, we advocate for a multidisciplinary perioperative management team including orthopaedic surgery, hematology, anesthesia and, as needed, other subspecialties and recommend preoperative transfusions for all patients with SCD to increase their Hb concentration to 10 g/dL before surgery. Patients above this level do not receive transfusions preoperatively at our institution, as Hb values that are too high can cause issues associated with hyperviscosity. Overall, approximately half of our patients in this study period received preoperative hematology consultations. Whereas previously, only patients with SCD with Hb values <10 g/dL would receive a hematology consult, we have since changed protocols at our institution and all patients with SCD will see hematology preoperatively for optimization. Additionally, anesthesia consultations are used for patients with further medical issues to optimize medical management before surgery. We feel that although the decision of whether to transfuse is one that is best made by hematologists,

Table 7

Demographic Data Pertaining to Those Patients Who Had a Perioperative Complication

Age (yr)	BMI (kg/m^2)	SCD Genotype	Preoperative Comorbidities	ASA classification	Surgery site (type)	Reason for Surgery	Preoperative Consultation	Type of Complication	Hospital Stay (d)
53	27.91	HbSC	Hypertension, obstructive sleep apnea, vasoocclusive crises, acute chest syndrome, pulmonary hypertension, PE, priapism, chronic kidney disease	3	Hip (THA)	Osteonecrosis	Cardiology, anesthesia, hematology	Pain crisis, AKI on CKD, bleeding due to supratherapeutic INR	9
71	28.67	HbSC	Hypertension, hypercholesterolemia, pulmonary hypertension, chronic kidney disease	3	Spine (L2-L3, L3-L4 laminectomy and medial facetectomy)	Spinal stenosis-radicular back pain	Anesthesia	Transfusion reaction	3
30	25.96	HbSS	Vasoocclusive crises, acute chest syndrome	3	Hip (right hip resurfacing)	Osteonecrosis	None	Pain crisis	4
27	20.99	HbSS	Acute chest syndrome	2	Hip (BMAC)	Osteonecrosis	None	Pain crisis	2
27	32.73	HbSS	Vasoocclusive crises	3	Hip (THA)	Osteonecrosis	Anesthesia, hematology, internal medicine	Acute chest syndrome, pain crisis	15
34	32.26	HbSS	Hypertension, acute chest syndrome, pulmonary hypertension, PE, chronic kidney disease	3	Hip (THA)	Osteonecrosis	Anesthesia, hematology, rheumatology	AKI, hyperkalemia	7
35	32.92	HbSS	Hypertension, acute chest syndrome, pulmonary hypertension, PE, chronic kidney disease	3	Knee (TKA)	Osteonecrosis	Hematology, IM, rheumatology	AKI	7
34	27.77	HbSS	Obstructive sleep apnea, vasoocclusive crises, acute chest syndrome, DVT, PE	3	Shoulder (BMAC)	Left humeral head osteonecrosis	Hematology	Pain crisis	5
30	25.96	HbSS	Vasoocclusive crises, acute chest syndrome	3	Hip (THA)	Osteonecrosis	None	Pain crisis	9
30	22.44	HbSS	Vasoocclusive crises, acute chest syndrome, priapism	2	Trauma (scaphoid nonunion repair and autograft bone transplant)	Scaphoid fracture	None	Pain crisis	3
24	22.13	HbSS	Vasoocclusive crises, acute chest syndrome, PE	3	Spine (posterior instrumentation T3-L4, ponte osteotomies T5-T10)	Scoliosis	Anesthesia, hematology, internal medicine	PE/DVT	5

AKI = acute kidney injury, ASA = American Society of Anesthesiologists, BMI = body mass index, BMAC = bone marrow aspirate concentrate, CKD = chronic kidney disease, Hb = hemoglobin, INR = international normalized ratio, PE/DVT = pulmonary embolism/deep vein thrombosis, SCD = sickle cell disease, THA = total hip arthroplasty, TKA = total knee arthroplasty

the understanding that patients with SCD are more prone to developing acute diastolic congestive heart failure than the general population is a caveat that a multidisciplinary approach brings to the table. And, even though our perioperative complication rate is low compared with what is reported in the literature, we would like to bring down our rates to zero percent. As such, in future studies, we plan to study the impact of strict adherence with these principles on postoperative complication rates in these patients with SCD after orthopaedic surgery procedures.

In conclusion, this is the one of the larger studies to date reporting on the epidemiology of orthopaedic complications in SCD and the postoperative complications observed in those undergoing orthopaedic surgery for these conditions. Our study demonstrates that despite increased perioperative risk, many patients with SCD can undergo orthopaedic surgery safely with low perioperative complication rates, particularly if these patients adhere to certain management principles, including a multidisciplinary team approach. These findings are especially important to both the patient and surgeon as orthopaedic surgeries on patients with SCD are becoming increasingly prevalent.

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