Low morbidity and mortality with COVID-19 in sickle cell disease: A single center experience

Preethi Ramachandran1 | Abhilash Perisetti2 | Balachandar Kathirvelu3 | Mahesh Gajendran4 | Snigdha Ghanta5 | Ifeanyichkwu Onukogu5 | Ted Lao5 | Faiz Anwer6

1 Department of Hematology and Oncology, Brookdale University Hospital and Medical Center, Brooklyn, New York
2 Division of Gastroenterology and Hepatology, University of Arkansas for Medical Sciences, Little Rock, Arkansas
3 Department of Rehabilitation Sciences, The University of Texas at El Paso, El Paso, Texas
4 Department of Internal Medicine, Texas Tech University Health Sciences Center El Paso Paul L Foster School of Medicine, El Paso, Texas
5 Department of Internal Medicine, Brookdale University Hospital and Medical Center, Brooklyn, New York
6 Department of Hematology/Oncology, Stem Cell Transplantation, Cleveland Clinic, Cleveland, Ohio

Abstract

Coronavirus disease 2019 (COVID-19) is caused by SARS-CoV-2 infection, which evolved into a global pandemic within a short time. Individuals with sickle cell disease (SCD) suffer from underlying cardiopulmonary comorbidities and are at risk of severe complications such as pneumonia, acute chest syndrome, thrombosis, stroke, and multiorgan failure. Whether COVID-19 poses a high risk of morbidity and mortality in SCD patients remains unclear. Patients with SCD and COVID-19 can present with overlapping clinical features such as respiratory symptoms with ground-glass infiltrates, hyperinflammatory state, and increased risk of thromboembolism. This highlights the need to maintain a low threshold for testing for COVID-19 infection among symptomatic and hospitalized SCD patients. We report a case series of nine hospitalized SCD patients diagnosed with COVID-19 from March 18, 2020 to April 30, 2020 at a tertiary medical center in New York City. The mean age of the study population was 27.9 years, and interval since onset of symptoms and hospital presentation was 1–2 weeks. All patients in our series improved and were discharged home. This limited study shows that SCD patients, who are perceived to be high risk, maybe somehow protected from severe symptoms and complications of COVID-19 infection.

KEYWORDS
anemia, general hematology, hematological oncology, hemoglobin disorders, sickle cell disease

1 | INTRODUCTION

Novel coronavirus disease (COVID-19) is caused by severe acute respiratory syndrome corona virus-2 (SARS-CoV-2) [1]. There have been more than 5 million cases worldwide with 355,942 deaths as of May 27, 2020 [2]. COVID-19 predominately targets the respiratory system causing acute respiratory distress syndrome (ARDS), which remains the major cause of morbidity and mortality in COVID-19. SARS-CoV-2 can also affect the gastrointestinal tract, and patients can present with altered taste, abdominal pain, and diarrhea [1,3,4]. Patients with COVID-19 can present with severe cytokine release syndrome (cytokine storm) affecting different organ systems [5]. Sickle cell disease (SCD) patients are at risk of developing severe complications if affected by a viral illness. It is unclear, if COVID-19 can cause serious complications in SCD patients, and if SCD itself or its complications can be a risk factor for severe COVID-19

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2020 The Authors. eJHaem published by British Society for Haematology and John Wiley & Sons Ltd.
### Table 1  
Demographics, clinical features, laboratory values, and outcomes

| Characteristic               | Mean       | SD         | Lab findings           | n  | %    |
|------------------------------|------------|------------|------------------------|----|------|
| Age                          | 27.9       | 7.2        | Anemia                 | 9  | 100  |
| BMI                          | 25.6       | 4.7        | Elevated bilirubin     | 8  | 88.9 |
| Female                       | 4          | 44.4       | Leukocytosis           | 5  | 55.6 |
| Race                         |            |            | Elevated ferritin      | 7  | 77.8 |
| African American             | 9          | 100        | Elevated ALT          | 1  | 11.1 |

### Symptoms

| Blood group                  | n  | %    |
|------------------------------|----|------|
| Fever                        | 7  | 77.8 |
| Myalgia                      | 6  | 66.7 |
| Cough                        | 3  | 33.3 |
| Back pain                    | 4  | 44.4 |
| Dyspnea                      | 1  | 11.1 |
| GI symptoms                  | 2  | 22.2 |
| Sore throat                  | 1  | 11.1 |
| Prev Complications due to SCD|    |      |
| Hgb F                        | 11.0| 8.5  |
| Hgb A1                       | 9.4 | 10.2 |
| Hgb A2                       | 2.9 | 1.1  |
| Hgb C                        | 5.0 | 15.0 |
| H/o transfusion              | 8  | 88.9 |
| Ferritin > 1000              | 4  | 44.4 |
| Acute chest                  | 3  | 33.3 |
| Avascular necrosis           | 2  | 22.2 |
| Pulm HTN                     | 2  | 22.2 |
| Pulmonary embolism           | 1  | 11.1 |
| Priapism                     | 1  | 11.1 |
| CVA                          | 1  | 11.1 |
| Comorbidities                |    |      |
| Asthma                       | 4  | 44.4 |
| Smoker                       | 1  | 11.1 |
| Home Medication              | n  | %    |
| Folic acid                   | 8  | 88.9 |
| Hydrea                       | 6  | 66.7 |
| Opiates                      | 8  | 88.9 |
| Others                       | 0  | 0    |
| Survival rate                | 9  | 100  |
| Shock                        | 1  | 11.1 |
| Ventilation                  | 0  | 0    |

| Outcomes                     | Mean | SD |
|------------------------------|------|----|
| Length of stay               | 7.1  | 1.9 |
| Survival rate                | 9    | 100|
| Shock                        | 1    | 11.1|

Abbreviations: ALT, alanine aminotransferase; AST, aspartate aminotransferase; CVA, cerebrovascular accidents; Hgb, hemoglobin; SD, standard deviation.

disease. In this case series, we describe individuals with a history of SCD hospitalized due to COVID-19, their clinical presentation, and outcomes.

### 2 METHODS

COVID-19 diagnosed adults (18 years or older) with a history of SCD (homozygous hemoglobin S [HbSS], compound heterozygous HbS and HbC [HbSC]) were identified from Brookdale University Health System between March 18 and April 30, 2020. The local institutional review board approved the study protocol and granted a waiver of informed consent due to its retrospective nature. The clinical characteristics, laboratory, and outcomes data were extracted from electronic medical records in a standardized report form. A total of 725 patients who tested positive for SARS-CoV-2 by reverse transcription-polymerase chain reaction in nasopharyngeal swab or sputum samples were screened, and 9 patients with SCD were identified. Quantitative data were shown as the mean ± standard deviation (SD) or as a percent-

### 3 RESULTS

Data from nine hospitalized SCD patients among 725 diagnosed with symptomatic COVID-19 were reported in this study. The demographic and clinical characteristics of these patients are shown in Table 1. The main symptoms at presentation were fever (77.8%), myalgia (66.7%), cough and back pain (33.3%) followed by less common symptoms including dyspnea, gastrointestinal symptoms, and sore throat. Preceding history of complications of SCD including iron overload (44.4%), acute chest syndrome (33.3%), pulmonary hypertension (22.2%), and avascular necrosis (22.2%) was reported among these patients. History of asthma was reported in 44.4%. Table 2.

Laboratory data showed anemia (100%) with mean hemoglobin (post) of 7.8 g/dL (SD 1.1), elevated bilirubin (88.9%), elevated ferritin (77.8%), and leukocytosis (55.6%). Laboratory values at baseline
and during hospitalization are summarized in Table 3. Home medications included folic acid (88.9%), opiate analgesics (88.9%), and hydroxyurea (66.7%). None of the patients were on L-glutamine, voxelotor, or crizanlizumab. All HBSS patients had HBS ranging from 49.1% - 92.5% and Fetal Hemoglobin (HBF) ranging from 1.5% to 30.4%. Around 50% of patients were treated with hydroxychloroquine and azithromycin. None of the patients received antiviral therapy or IL-6 inhibitor. About 66% of the patients needed simple blood transfusion support during their hospital admission as summarized in Table4. Vital signs, radiological features, management, and outcomes are noted in Table4. The duration of symptoms before presentation ranged between 1 and 2 weeks. All patients except one showed respiratory parenchymal changes that ranged from subtle hazy appearance to frank infiltrates (Figure 1). All of them had sickle cell crisis and received hydration and analgesics.

Age matched controls were compared with SCD for clinical outcomes. Fifty-three out of 725 were among those aged 18–40 years. Of these, 19 patients needed ICU admission with four needing intubation. Four died with mortality of 5.6%. Among the nine SCD patients, only one needed ICU admission without the need for intubation. No deaths were observed, and all were discharged. The average length of hospital stay was slightly longer in SCD (7.1 days) than the age matched control (6.8 days) as summarized in Table 5.

4 | DISCUSSION

Patients with SCD are a unique subset of hematological disease population who are postulated to be at higher risk of developing multiple and severe complications with COVID-19 due to multiple organ derangement due to SCD complications. Data on clinical manifestations of SARS-CoV-2 in SCD is scarce. SCD patients at baseline have anemia, increased risk of infections, and vaso-occlusive crisis (VOC). Acute respiratory illnesses, in general, are a major cause of mortality and morbidity in SCD due to increased risk of developing pneumonia, pulmonary VOC disease, and acute chest syndrome [6]. Infections are major causes of morbidity and mortality in SCD individuals due to tissue hypoperfusion, functional hyposplenism, disproportionately high inflammatory overload, or hypoventilation [7,8]. Furthermore, viral infections such as H1N1, seasonal influenza, Zika can present with increased virulence in these individuals [9-11]. If SARS-CoV-2 viral infection produces such hyperinflammatory response in SCD individuals, the interplay between symptoms or complications of SARS-CoV-2 in patients with SCD who has anemia at baseline, varying levels of hemoglobin variants such as Hb S, Hb F, iron overload, current or recent exposure to hydroxyurea, other prescription drugs, and underlying lung pathology remains unknown.

---

**Table 2** Clinical characteristics, comorbidities, and complications in COVID-19 SCD patients

| Case | Age | Gender | Sickle cell Type | Symptoms at presentation | Comorbidities | Duration of Symptoms | Previous SCD complications | Past 1 year admission |
|------|-----|--------|-----------------|-------------------------|--------------|---------------------|---------------------------|-----------------------|
| #1   | 27  | M      | HBSS           | Cough, fever, nausea, fatigue, myalgia, back pain | Asthma       | 1 week              | Ferritin > 1000, H/o transfusion | 19                    |
| #2   | 28  | F      | HBSS           | Back pain and headache | None         | 1 week              | Acute chest, pulmonary HT (TRJV > 2.5), H/o transfusion | 11                    |
| #3   | 21  | M      | HBSS           | Cough, fever, sore throat, nausea, fatigue, myalgia | Schizophrenia | 1 week              | Priapism, H/o transfusion | 1                     |
| #4   | 21  | M      | HBSS           | Fever, myalgia, back pain | None         | 5 days              | Acute chest, ferritin > 1000, avascular necrosis, H/o transfusion | NA                    |
| #5   | 31  | F      | hbsc           | Cough, fever, myalgia, dysgeusia, Rt hip pain, chest pain, loss of appetite | Asthma       | 2 days              | Pulmonary embolism | 2                     |
| #6   | 37  | M      | HBSS           | Fever, fatigue, myalgia, generalized weakness | None         | 2 weeks             | Microalbuminuria, vaso-occlusive episodes | 2                     |
| #7   | 40  | M      | HBSS           | Fever | CVA, seizure, DVT | 1 day | Acute chest, CVA, pulmonary HT (TRJV > 2.5), ferritin > 1000, H/o transfusion (chronic) | 2                     |
| #8   | 19  | F      | HBSS           | Fever, LOW BACK PAIN, AND LEG pain | Asthma       | 2 weeks             | H/o transfusion | 16                    |
| #9   | 27  | F      | HBSS           | Myalgia | Chronic Ulcers, Asthma | 1 week | Ferritin > 1000, avascular necrosis H/o transfusion | 3                     |

Abbreviations: CVA, cerebrovascular accident; DVT, deep vein thrombosis; HT, hypertension; NA, not available; TRJV, tricuspid regurgitant jet velocity.
7 | WHAT AND HOW

Presenting features of COVID-19 and SCD complications without
SARS-CoV-2 infection can overlap significantly and a high level of vigilance is needed while providing care to patients with SCD especially during the pandemic period. It remains to be studied how some of these pathophysiological pathways potentially interact to mitigate adverse effects of COVID-19.

SCD patients with COVID-19 have high ferritin levels, a finding common in severe SCD patients without COVID-19. SCD patients have high ferritin levels, a finding common in severe SCD patients without COVID-19. SCD patients have high ferritin levels, a finding common in severe SCD patients without COVID-19.

The overlap in pathophysiology of COVID-19 and SCD might contribute to more severe disease outcomes in individuals with SCD. This hypothesis is supported by the report of a 20-year-old individual with SCD who presented with ACS, severe back pain, and extremity pain. One individual recovered completely; however, the clinical course for the second individual is not known. In a case series, McCloskey et al. reported 10 SCD patients from the United Kingdom with favorable outcomes except for one patient for whom morbidity and mortality were attributed to multiple underlying comorbidities.

The pathophysiological processes of COVID-19 involve the inflammatory response (cytokine storm), which can lead to higher vascular permeability, extensive microthrombi formation, leading to organ failure, and death. Similarly, SCD patients can develop multiple pathophysiological changes due to vaso-occlusion (tissue hypoxia, increased adhesion to endothelium, increased permeability of vascular endothelium), hypoxia, and ischemic reperfusion injury (by reactive oxygen species) [17,18]. Due to the history of multiple transfusions, SCD patients have high ferritin levels, a finding common in severe SCD patients without COVID-19. SCD patients have high ferritin levels, a finding common in severe SCD patients without COVID-19. SCD patients have high ferritin levels, a finding common in severe SCD patients without COVID-19. SCD patients have high ferritin levels, a finding common in severe SCD patients without COVID-19.

The overlap in pathophysiology of COVID-19 and SCD might contribute to more severe disease outcomes in individuals with SCD. This hypothesis is supported by the report of a 20-year-old individual with SCD who presented with ACS, severe back pain, and extremity pain. One individual recovered completely; however, the clinical course for the second individual is not known. In a case series, McCloskey et al. reported 10 SCD patients from the United Kingdom with favorable outcomes except for one patient for whom morbidity and mortality were attributed to multiple underlying comorbidities.

TABLE 3 Laboratory data in COVID-19 SCD patients

| Case | Hb Pre | WBC Pre | ALB Pre | Creatinine Pre | PT Pre | PTT Pre | Fibrinogen Pre | D-dimer Pre | ALT Pre | AST Pre | Bilirubin Pre | Lactate Pre | CRP Pre | Ferritin Pre | Troponin Pre | LDH Pre | Pre Post | Post Post | Pre Post | Post Post | Pre Post | Post Post | Pre Post | Post Post | Pre Post | Post Post | Pre Post | Post Post |
|------|--------|---------|--------|-------------|-------|--------|--------------|-------------|--------|--------|--------------|------------|-------|-------------|-------------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| #1   | 8.3    | 8.0     | 9.1    | 6.5         | 0.5   | 0.45   | 5.6          | 0.5         | 0.45   | 1.3    | 1.43     | 40         | 365    | NA         | NA         | 1072   | NA      | 24      | 31      | 27      | 84      | 0.2      | 7.9     | 1.7      | NA      | 15      | 7.6     | NA      | 1210    | 0.012    | 0.012    | 605     | 1881    |
| #2   | 8.0    | 6.3     | 12.8   | 6.6         | 0.6   | 0.74   | 7.6          | 0.6         | 0.74   | 1.4    | NA       | 25         | NA     | 623    | NA         | 800     | NA      | 19      | 18      | 34      | 29      | 6.2      | 3.5     | 0.8      | NA      | 0.012   | 900     | NA      | 768     | 637     |
| #3   | 10.0   | 9.6     | 8.2    | 6.6         | 0.6   | 0.55   | 1.9          | 0.6         | 0.55   | 1.2    | NA       | 31         | NA     | 150    | NA         | 125     | NA      | 12      | 45      | 21      | 37      | 2.3      | 2.1     | 0.8      | NA      | 0.012   | 935     | NA      | 136     | 968     |
| #4   | 8.8    | 6.7     | 9.1    | 6.6         | 0.5   | 0.57   | 2.7          | 0.5         | 0.57   | 1.3    | 1.2      | 35         | 40.3   | NA     | NA         | 500     | NA      | 22      | 35      | 30      | 29      | 3.6      | 3.2     | 0.9      | NA      | 58.8    | 550     | 975     | 79.6    |
| #5   | 9.0    | 8.6     | 7.3    | 6.6         | 0.6   | 0.71   | 9.8          | 0.6         | 0.71   | 1.2    | NA       | 31         | NA     | 700    | NA         | 243     | NA      | 27      | 17      | 28      | 25      | 1.1      | 1.4     | 0.8      | NA      | 0.012   | 992     | NA      | 719     |
| #6   | 10.0   | 8.1     | 8.1    | 5.3         | 0.94  | 3.74   | 3.41        | 0.94        | 3.74   | 1.18   | 1.93     | 26.3       | 304    | NA     | 1102       | 44514  | NA      | 36      | 10      | 45      | 21      | 3.9      | 3.9     | 1.9      | NA      | 0.012   | 974     | NA      | 301     | 1673    |
| #7   | 8.0    | 5.8     | 5.6    | 6.5         | 0.5   | 0.74   | 4.2          | 0.5         | 0.74   | 1.2    | NA       | 35         | NA     | 800    | NA         | 300     | 100     | 30      | 100     | 100     | 90      | 0.9      | 0.9     | NA      | 0.012   | 5000    | 3830    | 0.012   | 0       | 442     | 757     |
| #8   | 10.0   | 7.6     | 9.9    | 6.5         | 0.5   | 0.53   | 4.2          | 0.8         | 0.53   | 1.2    | 1.26     | 25         | 221    | NA     | NA         | 18      | 51      | 32      | 70      | 1.9      | 1.37    | 0.8      | 1.7     | 3.8     | 64      | 137     | 1340    | 0.012   | NA      | 788     | 1215    |
| #9   | 9.0    | 8.0     | 11     | 24          | 0.6   | 0.6    | 16.5         | 0.6         | 1.1    | 1.27   | 32       | 281        | 488    | NA     | 529        | 17      | 24      | 31      | 49      | 2.7      | 2.7     | 1.1      | 2.7     | 3.9     | NA      | 5000    | 0.012   | 0.012   | 788     | 1096    |
| Case | Age | Gender | Home SCD medications | COVID medication | Other medication | Blood transfusion | Respiratory rate/min | O$_2$ nadir | Radiological finding | Respiratory support | ICU admission | Outcome |
|------|-----|--------|----------------------|------------------|-----------------|------------------|---------------------|-------------|---------------------|-------------------|--------------|---------|
| #1   | 27  | M      | Folic acid, hydrea, opiates | No               | No              | None             | 0                   | 20          | 95%                 | Nasal cannula    | No           | Discharged |
| #2   | 28  | F      | Folic acid, opiates       | Yes              | No              | Doxycycline      | 1 (Day 5)           | 20          | 95%                 | No               | No           | Discharged |
| #3   | 21  | M      | Folic acid, hydrea, opiates | Yes              | Yes             | Ceftriaxone      | 1 (Day 3)           | 40          | 85%                 | HFNC             | No           | Discharged |
| #4   | 21  | M      | Folic acid, hydrea, opiates | No               | Yes             | Ceftriaxone, doxycycline | 0                  | 20          | 95%                 | Nasal CANNULA    | No           | Discharged |
| #5   | 31  | F      | Folic acid, opiates       | Yes              | Yes             | None             | 0                   | 19          | 95%                 | No               | No           | Discharged |
| #6   | 37  | M      | None                   | No               | Yes             | Cefepime, vancomycin | 4 (Day 2 and 4)     | 32          | 88%                 | NIPPV            | Yes          | Discharged |
| #7   | 40  | M      | Folic acid, hydrea, opiates | No               | No              | None             | 3 (Day 1 and 7)     | 21          | 91%                 | Nasal cannula    | No           | Discharged |
| #8   | 19  | F      | Folic acid, hydrea, opiates | Yes              | No              | Clindamycin, doxycycline | 2 (Day 3)           | 18          | 98%                 | No               | No           | Discharged |
| #9   | 27  | F      | Folic acid, hydrea, opiates | NA               | NA              | Ceftriaxone, vancomycin | 3 (Day 1 and 3)     | 18          | 94%                 | No               | No           | Discharged |

Abbreviations: Azi, azithromycin; HFNC, high flow nasal cannula; NA, not available; NIPPV, nasal intermittent positive pressure ventilation; Plaq, plaquenil.
SCD mostly affects the African American race [20]. The same ethnicity showed a strong association with severe COVID-19 disease symptoms [21]. It is unclear if severe COVID-19 presentation highlights the social disparities at play or the high underlying comorbidity burden which is present in this population. However, this case series and recently published literature review suggest that outcomes are not necessarily worse for SCD patients. All reported cases had anemia, and around 80% of our patients had predominantly HBS hemoglobin (range: 49.1-92.5) with higher HBF (range: 1.5-30.4), use of opiates, folic acid, and hydroxyurea was documented in 60–80% of these cases. It is unclear whether hemoglobin S or Hemoglobin F or prescription medication use in these patients provided any protective effect from severe complications of COVID-19 in this hospitalized population.

8 | LIMITATIONS

Limitations of our data include the retrospective nature of our data captured in this case series. An alternative explanation of the low risk of complications includes the younger age of patients with SCD, low incidence of HTN, and their low comorbidity disease burden. To further explore this issue of complications with COVID-19, preclinical models and larger clinical studies with more data or registry studies need to be conducted and updated frequently [22]. Such studies can provide knowledge about preventative strategies and risk mitigation for COVID-19 patients. Targeted screening of SCD patients for COVID-19 symptoms is needed to identify the disease at the early stages for prompt monitoring and intervention.

CONFLICT OF INTEREST

The authors declare no conflict of interest.
AUTHOR CONTRIBUTIONS

Conceptualizations, methodology, Supervision: PR, FA; manuscript writing, reviewing, and editing: PR, BK, FA; statistical and data analysis: AP, MG; data collection & literature review: SG, IO, TL, AP.

ORCID

Preethi Ramachandran https://orcid.org/0000-0003-3032-8886

REFERENCES

1. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020;395(10223):497–506.
2. Worldometer M, 2020. Coronavirus Update (live): 4,989,095 cases and 324,970 deaths from COVID-19 virus pandemic – Worldometer 2020 https://www.worldometers.info/coronavirus/#countries. Accessed May 27, 2020.
3. Aziz M, Perisetti A, Lee-Smith WM, Gajendran M, Bansal P, Goyal H, et al. Taste changes (dysgeusia) in COVID-19: a systematic review and meta-analysis. Gastroenterology. 2020. In Press.
4. Perisetti A, Gajendran M, Boregowda U, Bansal P, Goyal H. COVID-19 and gastrointestinal endoscopies: current insights and emergent strategies. Dig Endosc. 2020;32:715–22.
5. Jose RJ, Manuel A. COVID-19 cytokine storm: the interplay between inflammation and coagulation. Lancet Respir Med. 2020;8:e46-e47.
6. Srinivasan A, Wang WC, Gaur A, Smith T, Gu Z, Kang G, et al. Prospective evaluation for respiratory pathogens in children with sickle cell disease and acute respiratory illness. Pediatr Blood Cancer. 2014;61(3):507-511.
7. Rogers ZR, Wang WC, Luo Z, Iyer RV, Shalaby-Rana E, Dertinger SD, et al. Biomarkers of splenic function in infants with sickle cell anemia: baseline data from the BABY HUG Trial. Blood. 2011;117(9):2614-2617.
8. Halasa NB, Shankar SM, Talbot TR, Arboagast PG, Mitchel F, Wang WC, et al. Incidence of invasive pneumococcal disease among individuals with sickle cell disease before and after the introduction of the pneumococcal conjugate vaccine. Clin Infect Dis. 2007;44(11):1428-1433.
9. Strouse JJ, Reller ME, Bundy DG, Amoako M, Cancio M, Han RN, et al. Severe pandemic H1N1 and seasonal influenza in children and young adults with sickle cell disease. Blood. 2010;116(18):3431-3434.
10. Arzuza-Ortega L, Polo A, Pérez-Tatis G, López-García H, Parra E, Pardo-Herrera LC, et al. Fatal sickle cell disease and zika virus infection in girl from Colombia. Emerg Infect Dis. 2016;22(5):925–27
11. Vichinsky EP, Neumayr LD, Earles AN, Williams R, Lennette ET, Dean D, et al. Causes and outcomes of the acute chest syndrome in sickle cell disease. National Acute Chest Syndrome Study Group. N Engl J Med. 2000;342(25):1855–65
12. Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet. 2020;395(10223):507–13.
13. Nur E, Gaartman AE, van Tuijno CFJ, Tang MW, Biemond BJ. Vasculitic crisis and acute chest syndrome in sickle cell disease due to 2019 novel coronavirus disease (COVID-19). Am J Hematol. 2020;95:725–6.
14. McCloskey KA, Meenan J, Hall R, Tsitsikas DA. COVID-19 Infection and Sickle Cell Disease: A UK Centre Experience. Br J Haematol. 2020;190:e57–e58.
15. Hussain FA, Njoku FU, Saraf SL, Molokie RE, Gordeuk VR, Han J. COVID-19 Infection in Patients with Sickle Cell Disease. Br J Haematol. 2020;189:851–2.
16. Xu H, Zhong L, Deng J, Peng J, Dan H, Zeng X, et al. High expression of ACE2 receptor of 2019-nCoV on the epithelial cells of oral mucosa. Int J Oral Sci. 2020;12(1):8.
17. Ansari J, Gavins FNE. Ischemia-reperfusion injury in sickle cell disease: from basics to therapeutics. Am J Pathol. 2019;189(4):706-18.
18. Chen J, Hobbs WE, Le J, Lenting PJ, de Groot PG, López JA. The rate of hemolysis in sickle cell disease correlates with the quantity of active von Willebrand factor in the plasma. Blood. 2011;117(13):3680-3
19. Terpos E, Ntanasis-Stathopoulos I, Elamby I, Kastritis E, Sergentanis TN, Politou M, et al. Hematological findings and complications of COVID-19. Am J Hematol. 2020;95(7):834-47
20. Lee L, Smith-Whitley K, Banks S, Puckrin G. Reducing health care disparities in sickle cell disease: a review. Public Health Rep. 2019;134(6):599–607.
21. Yancy CW. COVID-19 and African Americans. JAMA. 2020. 10.1001/ jama.2020.6548. Online ahead of print.
22. Panepinto JA, Brandow A, Mucalo L, Yusuf F, Singh A, Taylor B, et al. Coronavirus disease among persons with sickle cell disease, United States, March 20–May 21, 2020. Emerg Infect Dis. 2020;26(10).

How to cite this article: Ramachandran P, Perisetti A, Kathirvelu B, et al. Low morbidity and mortality with COVID-19 in sickle cell disease: A single center experience. eJHaem. 2020;1:608-614. https://doi.org/10.1002/jha2.87