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# Perioperative sickle cell anemia considerations for total hip arthroplasty: case report

## *Consideraciones perioperatorias de la anemia de células falciformes para la artroplastia total de cadera: Reporte de caso*

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**Palabras clave:** Anemia de células falciformes, Artroplastia de Reemplazo de Cadera, Informes de Casos, Anestesia, Periodo Perioperatorio



## Abstract

Sickle cell anemia or drepanocytosis is a hemoglobinopathy with autosomal recessive inheritance. A longer life expectancy of these patients and the fact that 50% have aseptic osteonecrosis of the hip make total hip arthroplasty a frequent procedure. We present the case of a 34-year-old male diagnosed with homozygous sickle cell disease scheduled for surgery in the operating room. Our aim is to offer perioperative strategies based on a multidisciplinary approach among anesthesiologists, surgeons, and hematologists to avoid complications of the disease itself, exacerbated by moderate-high risk surgeries.

## Resumen

La anemia de células falciformes o drepanocitosis es una hemoglobinopatía con herencia autosómica recesiva. La mayor esperanza de vida de estos pacientes y el hecho de que el 50% presenten osteonecrosis aséptica de cadera determinan que la artroplastia total de cadera sea un procedimiento frecuente. Presentamos el caso de un varón de 34 años diagnosticado de drepanocitosis homocigota programado en quirófano para dicha intervención quirúrgica. Nuestro objetivo es ofrecer unas estrategias perioperatorias basadas en un abordaje multidisciplinar entre anestesiólogos, cirujanos y hematólogos para evitar complicaciones propias de la enfermedad, exacerbadas por cirugías de riesgo moderado-alto.

## Introduction

Sickle cell anemia (SCA) or sickle cell disease is an autosomal recessive inherited hemoglobinopathy characterized by the presence of sickle hemoglobin (HbS), absent in healthy individuals. The prevalence of the gene is 5% and is predominantly black.[1,2] Homozygous individuals (HbSS) are characterized by chronic hemolytic anemia and repeated episodes of acute vascular occlusion leading to heart attacks, intense pain, and organ dysfunction, known as vaso-occlusive crisis (VOC).[1] The perioperative period is associated with

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increased disease exacerbations[2] and complications.[3] Perioperative management requires a multidisciplinary approach, including surgeons, anesthesiologists, post-anesthetic care unit (PACU) staff, and hematologists.[3]

## Clinical case

We present the case of a 34-year-old male from Senegal, diagnosed with HbSS SCA, with bilateral osteonecrosis of the hip due to his disease, who was proposed for total arthroplasty surgery.

### *Clinical findings, diagnostic evaluation, and interventions*

He was assessed in pre-anesthesia with a personal history of 2 episodes per year of VOC, costal pain, lumbar pain, hip pain, and chronic hemolytic anemia (CHA) requiring annual transfusion of 8 to 10 red blood cell units concentrates. On physical examination he presented chronic ulcers in malleoli compatible with osteonecrosis of long bones. He had had marked right hip pain for 2 years, with magnetic resonance imaging and scintigraphy showing data suggestive of ischemic bone involvement. Hydroxyurea, folic acid and first-stage analgesics were used as basic treatment.

Hemogram, biochemistry, coagulation, electrocardiogram, and chest radiography (CXR) were requested, highlighting hemoglobin (Hb) of 90 g/L and hematocrit (Hto) of 0.25 L/L. Typing was done scrutinizing positive irregular antibodies and phenotype of the sample: c+, e +, k+, s+, Jka+, Kpb+, Lea+, Lub+, M+, N+, P1+.

Hematology was consulted, performing a Hb study: $Hb_{A2}$: 5.5%; HbF 6.6%; HbS 77.6%; hemocytometer and cytological study of peripheral blood with reticulocytes $299.9 \times {}^{109}$/L (10.8%), abundant sickle cells and a hemolysis study with haptoglobin 1 mg/dL. He recommended intravenous hydration 12 hours before surgery, which was performed with 2 L of ringer lactate (RL) and pre-operative transfusion of a red blood cell unit to maintain Hb at 100 g/L or Hto 0.30 L/L, without exceeding these levels.

He was monitored intraoperatively with continuous electrocardiogram II and V5, pulse oximeter ($SpO_2$) and non-invasive blood pressure every 5 minutes. An amount of 3 mg of intravenous midazolam were administered and intradural anesthesia was performed with 13 mg of hyperbaric bupivacaine by medial L3 to L4 puncture with 25-G pencil tip needle, without difficulty. An amount of 2 g of intravenous cefazolin were given as antibiotic prophylaxis and supplemental oxygen with nasal cannula (NC) at 2 liters per minute (Lpm). The patient was positioned in left lateral decubitus with thermal blanket and fluid heater for maintenance of bladder temperature between 35.5 °C and 36.5 °C.

During the surgical procedure (120 min) the patient maintained 99% $SpO_2$ and mean arterial pressure above 70 mm Hg. Two red blood cells units were transfused intraoperatively by moderate-abundant bleeding. 3.5 L of RL were administered intraoperatively, collecting a urine output of 500 mL.

### *Calendar*

Not specified by the clinical case format.

### *Follow-up and result*

At the end of the surgical procedure, the patient remained in the PACU for 24 hours. During this period, analgesia with continuous perfusion of morphine chloride at 1.5 mg/h, dexketoprofen 50 mg, and metamizole 2-g intravenous alternating every 4 hours were administered. Analgesic rescue was required, with morphic chloride boluses, total 10 mg. Oxygen therapy was added with NC at 2 Lpm with $SpO_2$ 99% and respiratory physiotherapy at 10 breaths every 2 hours, respecting sleep. An amount of 3 L of RL were administered. His stay at the PACU was smooth. In the following days, a daily hemogram was taken, requiring transfusion of 2 red blood cells units at 48 hours per 78 g/L Hb. He was discharged 4 days after surgery.

## Discussion

The SCA is native to equatorial Africa and southwestern Asia, presenting less aggressive phenotypes in this region.[4] Patients undergo at least 1 orthopedic surgery in their lifetime,[5,6] with osteonecrosis of the femoral head in 50% of them,[6,7] so they are candidates for hip arthroplasty.

In a healthy population 97% of Hb is type A, formed by 2 chains $\alpha$ and 2 $\beta$ joined by the hemo group. The rest is $Hb_{A2}$ and HbF. In HbSS individuals HbS assumes up to 95%, with HbA absent, normal $Hb_{A2}$ and HbF figures between 5% and 10%.

HbS originates from a mutation of the gene encoding the $\beta$ string. It determines the substitution of glutamic acid for valine, causing the loss of its negative charge, which destabilizes the structure of the oxygenated Hb, generating reactive radicals, lowering the permeability of the deoxygenated Hb and the solubility of the erythrocyte, and favoring dehydration, fragility, and precipitation of the HbS3,[8] polymers. Mechanical and oxidative stress in the vascular endothelium causes inflammation, expression of adhesion molecules, and decreases nitric oxide with consequent intermittent and recurrent VOCs, along with CHA due to the destruction of erythrocytes.[3]

This alteration in micro and macrocirculation causes organ damage, with pulmonary and neurological affectation being the main causes of morbidity and mortality, with special mention of acute thoracic

syndrome (ATS) favored by infections, fat embolism after bone infarction, pulmonary infarction, or surgical procedures,[6] which is defined as a new infiltrate in CXR that includes at least 1 lobar segment, excluding atelectasis.

Up to 19% of complications associated with SCA have been reported in hip arthroplasty,[6] an increase in intraoperative bleeding and up to 50% alloimmunization,[4,6,7] due greatly, to the racial disparity of erythrocyte groups between donor and recipient.[8]

Surgical risk is a predictor of complications: low risk (inguinal hernia, myringotomy, cutaneous, nasal, *hallux valgus*, etc.), medium (intrabdominal, genitourinary, major orthopedic, etc.) and high (intracranial, vascular, and intrathoracic).[3,5,6] The number of hospitalizations and crises in the previous year are independent predictors of VOC.[9] High-risk surgery and history of lung disease are predictors of postoperative ATS.[9] An CXR should be requested, given the high frequency of pulmonary involvement and functional tests to establish restrictive pathology depending on the case. In advanced disease we find pulmonary hypertension and severe hypoxemia.[5] In patients with a history of cardiac dysfunction, an echocardiogram would be of interest.[3]

A blood count, biochemistry, and coagulation are recommended to determine pre-operative Hb level and kidney function. Some authors recommend requesting HbS%[6] despite other studies stating that the proportions of F and S Hb are not sensitive enough as predictors of risk to be routinely requested in pre-anesthesia.[5] A broad erythrocyte phenotype should be requested at screening for irregular antibodies.[3,4,8]

Prophylactic blood transfusion has been used to dilute sickle cells with normal erythrocytes[4] by 2 methods: an aggressive regime (decrease HbS to less than 30% and achieve Hb 100 g/L by exchange transfusion and simple chronic transfusion) or conservative (increase Hb to 100 g/L by simple transfusion), with the incidence of complications related to similar disease.[3–6,9,10] There is little evidence that pre-operative transfusion versus non-transfusion prevents ATS,[10] and therefore the criteria for initiating transfusion should be individualized per patient, surgical intervention, baseline Hb and cardiopulmonary reserve.[3,5] It could be concluded that prophylactic transfusion is not necessary for low-risk surgeries, while at moderate-high risk it might be beneficial to transfuse for Hb 100 g/L, using a conservative regime.

The classic known factors favoring the polymerization of HbS are dehydration, hypothermia, acidosis, hypoxia, vascular stasis, and infection,[3] which have been treated prophylactically.[2]

Several authors recommend intensifying pre-operative hydration[6,8,9] without a high degree of evidence,[2,5] with an alternative being a clear liquid fasting up to 2 to 4 hours before the intervention.

Intraoperative monitoring includes temperature monitoring,[6,9] using active heat measurements. The mechanism by which hypothermia can trigger VOC has been described as an exaggerated reflex of vasoconstriction that limits flow to the medullary bone. On the other hand, this reflex is reduced in anaesthetized patients (with a tendency to hypothermia), and there is no clear relationship between hypothermia and VOC.

Avoiding hypoxia has been the *golden* standard in perioperative management.[2] The use of intraoperative hyperoxygenation or unnecessary supplemental oxygen in the postoperative period does not confer prophylaxis against complications and if prolonged, may depress erythropoiesis in CHA[2,5] patients. However, it is a widely used measure[6–9] and postoperative monitoring of $SpO_2$ is mandatory.

Theoretically, locoregional anesthesia causes venous stasis in the blocked area and compensatory vasoconstriction in the rest. However, in clinical practice, there is no difference in morbidity and mortality as per the anesthetic technique used.[3,5,6,9]

The use of tourniquets has been a subject of controversy. Available evidence suggests that, when strictly necessary, they can be used without complications in most patients, as the risk, although present, is very rare.[7]

Analgesia should start early. Anti-inflammatories are effective for bone pain. The most commonly used opioids are morphine and fentanyl, which are also included as an analgesic rescue. Locoregional analgesia offers better results, given the tolerance and addiction to opioids issues associated with these patients after multiple admissions. This last alternative limits pulmonary complications[2] and hypoventilation that could trigger ATS.[3]

In case of VOC the appearance of a ATS should be closely monitored.[5] ATS usually develops around day 3 after surgery. Incentive spirometry pre-operatively and postoperatively decreases the incidence of ATS.[3] Treatment with bronchodilators, supplemental oxygen, adequate analgesia, and broad-spectrum antibiotic therapy slow their progression. Transfusion improves oxygenation.

Morbidity and mortality of SCA have decreased in the last 2 decades, with a life expectancy of at least until mature adulthood, therefore, the number of surgical interventions has increased, especially those of an orthopedic nature.

### *Patient management*

Our patient did not have any complications associated with the disease. Locoregional anesthesia was used. The addition of intrathecal morphine would have been a good analgesic alternative; however, our center has no experience in this modality, which is the main weakness of our case. In the postoperative period, adequate pain control was maintained with intrave-

nous analgesia and normothermia, blood losses were replaced and $SpO_2$ was monitored. The patient was positioned in lateral decubitus without incidences, since the theoretical venous stasis of the declivity zone of this posture does not show a greater incidence of complications. The high need for transfusion is worth mentioning, in total 5 red blood cells units, in a surgery that in our center presents a low transfusion rate in a regulated manner, as in the exposed case. The main problem with this therapy is the patient's previous alloimmunization.

### *Lessons learned*

The pre-operative study should detect the frequency and severity of VOC in recent years, the surgical risk, transfusion requirements and the existence of lung, kidney, and brain damage.

Orthopedic procedures patients with SCA have a higher risk of fatty embolism and intraoperative bleeding, which consequently prolongs the duration of the surgery due to technical difficulty. Mortality is secondary to pulmonary complications, unlike the population free of this genetic alteration, where it is caused by cardiovascular and thromboembolic causes.[6]

For total hip arthroplasty, with a moderate surgical risk, we could adopt the following measures in order to avoid the most feared complications: prophylactic transfusion up to 10 mg/dL Hb to improve oxygen transport, limit the fasting period of clear liquids and/or intravenous hydration before procedure, maintaining normothermia, incentive spirometry pre and postprocedure, adequate analgesia, and avoiding all those circumstances that generate hypoxemia.

## Patient perspective

The patient perceived that the preparation before the surgical intervention and the perioperative management performed, including his stay in the 24-hour PACU, were necessary to minimize the risk of VOC.

## Ethical responsibilities

**Protection of humans and animals.** The authors state that no human or animal experiments have been carried out for this research.

**Data confidentiality.** The authors state that they have followed their workplace protocols on the publication of patient data.

**Right to privacy and informed consent.** The authors state that no patient data appears in this article. Informed written consent was obtained for the publication of the case, protecting the patient's identity. This document is held by the corresponding author.

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## Conflicts of interest

All authors declare no conflict of interest.

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