Impaired blood rheology plays a role in the chronic disorders associated with sickle cell- hemoglobin C disease

Nathalie Lemonne, Yann Lamarre, Marc Romana, Marie-Dominique Hardy-Dessources, François Lionnet, Xavier Waltz, Vanessa Tarer, Danielle Mougenel, Benoît Tressières, Marie-Laure Lalanne-Mistrih, et al.

To cite this version:

Nathalie Lemonne, Yann Lamarre, Marc Romana, Marie-Dominique Hardy-Dessources, François Lionnet, et al.. Impaired blood rheology plays a role in the chronic disorders associated with sickle cell- hemoglobin C disease: Blood viscosity in hemoglobin SC disease. Haematologica, Ferrata Storti Foundation, 2014, pp.74-75. inserm-01081709

HAL Id: inserm-01081709
https://www.hal.inserm.fr/inserm-01081709
Submitted on 10 Nov 2014

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers. L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Impaired blood rheology plays a role in the chronic disorders associated with sickle cell-hemoglobin C disease

Nathalie Lemonne1,* , Yann Lamarre2,3,4,* , Marc Romana2,3,4, Marie-Dominique Hardy-Dessources2,3,4, François Lionnet5, Xavier Waltz2,3,4, Vanessa Tarer1, Danielle Mougene1, Benoît Tressières6, Marie-Laure Lalanne-Mistrih2,3,4,6, Maryse Etienne-Julan1,2,3,4 and Philippe Connes2,3,4,7,8

* These authors contributed equally to this work

1Unité Transversale de la Drépanocytose, CHU de Pointe-à-Pitre, 97157 Pointe-à-Pitre, Guadeloupe; 2Inserm UMR 1134, Hôpital Ricou, CHU de Pointe-à-Pitre, 97157 Pointe-à-Pitre, Guadeloupe; 3Université des Antilles et de la Guyane, 97157 Pointe-à-Pitre, Guadeloupe; 4Laboratory of Excellence GR-Ex « The red cell: from genesis to death », PRES Sorbonne Paris Cité, 75015, Paris, France ;5Centre de Référence de la Drépanocytose, Hôpital Tenon, AP-HP, Paris, France; 6 Centre d’Investigation Clinique Antilles Guyane, Inserm/DGOS CIC 1424, CHU de Pointe-à-Pitre, 97157 Pointe-à-Pitre, Guadeloupe; 8Laboratoire ACTES EA3596, Pointe à Pitre, Guadeloupe; 8Institut Universitaire de France, Paris, France.

Key words: Sickle cell disease, sickle cell-hemoglobin C disease, blood viscosity, otologic disorders, retinopathy

Running title: Blood viscosity in hemoglobin SC disease

Word count: 1069; Figures: 0; Tables: 1

Corresponding author

Philippe Connes

Inserm UMR 1134, Hôpital Ricou, CHU de Pointe-à-Pitre, 97157 Pointe-à-Pitre, Guadeloupe

Email: pconnes@yahoo.fr
Lionnet et al.\textsuperscript{1} recently reported a high prevalence of retinopathy (RET) and otologic disorders (OTD) in patients with sickle cell-hemoglobin C disease (SC), while a significant number of patients had renal diseases (mainly glomerulopathy; GLO) and osteonecrosis (OST). The pathophysiological processes of these complications in SC are not well defined, although blood hyperviscosity has been suspected, but never tested to the best of our knowledge, as responsible for several chronic complications in SC disease\textsuperscript{1,2}. The aim of this study was to analyze the associations between hematological and hemorheological parameters and chronic complications in adult SC patients.

Ninety consecutive adults with SC (M/F: 40/50; mean age: 38 ± 13 yr) were enrolled in the study. All patients were at steady state at study entry, i.e., no phlebotomy or blood transfusions in the previous three months, and absence of acute episodes (infection, vaso-occlusive crisis (VOC), acute chest syndrome (ACS), stroke, priapism) at least three months before enrollment. Pregnancy or breast feeding were also exclusion criteria. The study was conducted in accordance to the Declaration of Helsinki, and approved by the Regional Ethics Committee (registration number: 2010-A00244-35). Written informed consent was obtained from all participants.

History, presence of chronic disorders, and acute event occurrence during the previous year of study were obtained from retrospective chart review by two physicians. Patients under regular phlebotomy protocols, but without any phlebotomy in the 3 months preceding the study were identified. Phlebotomy is usually performed in symptomatic SC patients to avoid recurrent acute events\textsuperscript{3}, and has been prescribed by some when hemoglobin and/or hematocrit rise above 11 g/dL or 32\%, respectively, to prevent complications with suspected blood hyperviscosity\textsuperscript{4}. The optimal target hemoglobin level to reach under phlebotomy is unknown but our Sickle Cell Centre usually tries to reduce hemoglobin to 9.5-10.5 g/dL. In our study, SC patients with
values greater than 11g/dL and 32% but no clinical assessment of blood viscosity were categorized as having “theoretical hyperviscosity”.

Measurements of hematological and hemolytic parameters (bilirubin, lactate dehydrogenase, aspartate aminotransferase) were performed using standard methods. Blood viscosity, red blood cell (RBC) deformability, aggregation and disaggregation threshold (i.e., RBC aggregates strength) were measured as described.

Unpaired Student’s t-test and chi-square or Kappa coefficient test were used for continuous and categorical covariates, respectively. Association between several parameters was tested by Pearson correlation. The hemolytic component value was derived from hemolytic markers (bilirubin, lactate dehydrogenase, aspartate aminotransferase and reticulocytes) by principal component analysis.

The most prevalent chronic complications in our SC cohort were RET (60%), GLO (micro-/macro-albuminuria, 40%), OST (31%), and OTD (20%). Leg ulcers, pulmonary hypertension and cerebral vasculopathy/stroke were extremely rare (2% each), as were ACS (2%) and VOC (5%) during the study period. Few males (8%) had a history of priapism.

Patients with OTD (OTD+) had higher RBC count (p<0.05), and a tendency to higher hemoglobin level than patients without OTD (OTD-; p<0.1; Table 1). Blood viscosity was increased by 9.1% in OTD+ compared to OTD- patients (p<0.05). SC RET+ patients had lower RBC deformability than RET- (p<0.05; Table 1). No association was observed between hematological or hemorheological parameters and OST or GLO. Nevertheless, OST+ and GLO+ patients were older than OST- and GLO- individuals (p<0.001 and p<0.01, respectively). An association was found between RET and OST, with higher frequency of
OST+ in the RET+ (38%) than in the RET- (18%; p<0.05) groups. No association was found between the other complications.

In our cohort, 43% SC patients underwent phlebotomy, 74% of them on a regular basis (every 3 months). The frequency of RET+ and RET- patients treated by phlebotomy was not different, as 57.6% RET+ patients had phlebotomy vs. 42.4% RET- patients. Only a trend towards greater phlebotomy use was observed in OTD+ patients (64%; p<0.1). Most patients (88.6%) with “theoretical hyperviscosity” (hemoglobin>11g/dL/hematocrit>32%) were phlebotomized (p<0.01). Comparing patients with or without theoreticalhyperviscosity demonstrated no significant difference in blood viscosity (7.50±1.03 vs 7.22±.35 cP, respectively), whilehemoglobin and hematocrit were higher in the theoreticalhyperviscosity group (11.8±1.0 vs 11.2±1.3 g/dL and 32.3±2.5 vs 30.6±3.2 %, respectively; p<0.01), as expected. The cohort was divided according to the median measured viscosity, and patients with blood viscosity greater than median value were considered as having “true hyperviscosity”. No significant association was found between theoretical and true hyperviscosity (Kappa coefficient=0.09), or between blood viscosity and hemoglobin or hematocrit, (r=0.19 and r=0.18, respectively; p=0.16 in both cases).

Elevated blood viscosity was hypothesized to cause ischemia at the labyrinthine artery level, leading to cochlear damage. This is in agreement with our cohort where OTD+ patients had higher blood viscosity than OTD-. However, OTD+ had only a trend towards higher hemoglobin and similar hematocrit as OTD-. Blood viscosity is influenced by several factors, including hematocrit and hemoglobin, hence their clinical use to prescribe phlebotomy. However, this relationship was not significant in our cohort. Blood viscosity depends also on the rheological properties of RBCs: i.e., deformability and aggregation. For a given hemoglobin level, increased RBC deformability lowers blood viscosity while increased RBC
aggregation causes a rise. The complex contribution of each hemorheological factor on blood viscosity makes that blood viscosity may be elevated in some patients despite “normal” hematocrit and hemoglobin levels.

More importantly, most patients with “theoretical hyperviscosity” did not have high blood viscosity, and only 44% of patients with measured “true hyperviscosity” were phlebotomized. Thus, as periodic phlebotomy could be useful to decrease blood viscosity in hyperviscous SC patients as it is in patients with polycythemia vera\textsuperscript{10} or cyanotic congenital heart disease\textsuperscript{11}, our findings strongly suggest that blood viscosity measurements would allow better identification of SC patients at risk for OTD.

In contrast to OTD, RET was not associated with blood hyperviscosity. Instead, RBC deformability was decreased by 10% in RET+ compared to RET- patients. RBC deformability is critical for optimal tissue perfusion and adequate blood flow in the micro-/ macro-circulation\textsuperscript{12}, and reduced RBC deformability is associated with diabetic retinopathy\textsuperscript{13,14}. The effects of phlebotomy on RBC deformability in SC patients with RET have never been investigated, calling for further studies to address this question.

In conclusion, our study provides new data on the pathophysiology of several frequent chronic complications in SC disease. They clearly show that the clinical use of hemoglobin and hematocrit as surrogates for high blood viscosity in SC patients is not satisfactory for establishing treatment or determining risk for OTD. A prospective study to evaluate the relationships between blood rheology and the occurrence of acute complications is warranted.

**Acknowledgments**

We thank Dr. Martine Torres for critical review of the manuscript and editorial assistance. PhD funding for Y.L. was supported by the regional council of Guadeloupe. PhD
funding for X.W. was supported by the association “Ensemble contre la drépanocytose” and by the regional council of Guadeloupe.

**Authorship and Disclosures:**


We declare no conflict of interest.

**References**

Table 1: Hematological and hemorheological determinants of otologic disorders, retinopathy, osteonecrosis and glomerulopathy in SC patients.

<table>
<thead>
<tr>
<th></th>
<th>Otologic disorders (OTD)</th>
<th>Retinopathy (RET)</th>
<th>Osteonecrosis (OST)</th>
<th>Glomerulopathy (GLO)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OTD- (n = 64)</td>
<td>OTD+ (n = 16)</td>
<td>RET- (n = 33)</td>
<td>RET+ (n = 49)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>40 ± 13</td>
<td>37 ± 14</td>
<td>39 ± 14</td>
<td>35 ± 12</td>
</tr>
<tr>
<td>White blood cells (x10^9 L)</td>
<td>7.4 ± 2.6</td>
<td>7.0 ± 2.4</td>
<td>7.4 ± 2.6</td>
<td>7.6 ± 3.0</td>
</tr>
<tr>
<td>Platelet count (x10^9 L)</td>
<td>306 ± 154</td>
<td>292 ± 151</td>
<td>298 ± 166</td>
<td>302 ± 145</td>
</tr>
<tr>
<td>Red blood cells (x10^{12} L)</td>
<td>4.3 ± 0.6</td>
<td>4.7 ± 0.7*</td>
<td>4.3 ± 0.7</td>
<td>4.4 ± 0.7</td>
</tr>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>11.2 ± 1.1</td>
<td>11.8 ± 1.3</td>
<td>11.3 ± 1.2</td>
<td>11.4 ± 1.3</td>
</tr>
<tr>
<td>Hematocrit (%)</td>
<td>31.0 ± 2.7</td>
<td>32.1 ± 3.8</td>
<td>31.0 ± 2.9</td>
<td>31.3 ± 3.1</td>
</tr>
<tr>
<td>Hemolytic index (relative unit)</td>
<td>0.01 ± 0.98</td>
<td>-0.21 ± 0.96</td>
<td>-0.12 ± 1.07</td>
<td>0.02 ± 0.93</td>
</tr>
<tr>
<td>Blood viscosity (cP)</td>
<td>7.38 ± 1.17</td>
<td>8.10 ± 0.85*</td>
<td>7.60 ± 1.10</td>
<td>7.28 ± 1.32</td>
</tr>
<tr>
<td>RBC deformability (a.u)</td>
<td>0.43 ± 0.07</td>
<td>0.41 ± 0.06</td>
<td>0.45 ± 0.06</td>
<td>0.41 ± 0.05*</td>
</tr>
<tr>
<td>RBC aggregation (%)</td>
<td>49 ± 8</td>
<td>47 ± 11</td>
<td>50 ± 8</td>
<td>48 ± 10</td>
</tr>
<tr>
<td>RBC disaggregation threshold (s^-1)</td>
<td>320 ± 126</td>
<td>312 ± 132</td>
<td>317 ± 101</td>
<td>319 ± 140</td>
</tr>
<tr>
<td>Means ± SD.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- = absence of complication and + = presence of complication. Sensorineural OTD (requiring hospitalization or not) were recorded using previously defined criteria. Criteria used to define VOC and ACS events (within the previous year of study) were similar to those used in
previous studies performed in SCA adults\textsuperscript{7}.

Criteria used to define osteonecrosis and glomerulopathy were similar to those used in previous studies\textsuperscript{5,15}.

Difference between groups (*p<0.05; **p<0.01; ***p<0.001).\textsuperscript{5} Statistical trend (p<0.1).