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### Scientific Comment

# Tides within ourselves: how posture can affect blood volume, blood cells and clinical reasoning<sup>☆</sup>



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Over 120 years ago, Ernest Starling demonstrated that fluids and other molecules move back and forward from blood to the extravascular space, and that this movement is determined by the balance between hydrostatic and oncotic pressures acting within capillaries and interstitial spaces.<sup>1</sup> The first measurement of the effect of these forces on blood volumes (plasma and cells) was published in 1928 in a 32-page long paper in the *Journal of Clinical Investigation*. This paper elegantly demonstrated that total plasma volume decreases on average 11% after 30 min standing still, compared to the recumbent position, and that hematocrit increased proportionally, indicating no significant changes in total blood cell volume.<sup>2</sup> The authors interpreted their findings as the result of the passage of water and other diffusible solutes through the capillary wall, due to an increase in hydrostatic pressure within blood vessels. Nearly thirty years later, using radionuclide-labeled red blood cells and a color dye that binds to albumin, Fawcett and Wynn evaluated the impact of these movements on parameters of the complete blood count (CBC) in healthy individuals and in patients with clinical edema and/or low albumin concentrations.<sup>3</sup> The standard experimental procedure consisted in subjects remaining in the horizontal position for 12 h, and then standing up for 1 h (slow walking was allowed during this period). Blood was collected 15 and 60 min after rising. The horizontal position was then resumed, and additional samples were obtained after the same time-points to evaluate whether changes were reversible. The study confirmed a mean decrease in plasma volume of 10.8% (equivalent to around 500 mL in a 70 kg adult) after 15 min, which

remained stable after one hour. This change was completely reversed after lying down again, with a mean increase in total plasma volume of 12.5% in healthy subjects. These shifts of total plasma volume were accompanied by inverse changes in hematocrit, which increased 6.6% after one hour of standing, and decreased 7.0% after resuming the horizontal position. Interestingly, the magnitude of these changes were much higher in patients with edema or hypoproteinemia, in whom the mean decrease in total plasma volume was 15.7% after one hour standing, and the mean hematocrit increase was 12.3%. Of note, while the change in hematocrit was completely reversed after returning to the recumbent position, the behavior of total plasma volume was somewhat different, in that a greater increase in total plasma volume was observed after lying down, with a mean value of 21% that reaching a 30% increase in some patients.<sup>3</sup> In 1988, Leppanen and Grasbeck evaluated the effect of shifting posture (from supine to seated to standing in different orders; 15 min in each position) in 22 healthy women. Observed changes were more evident when comparing the supine to standing position, and statistically significant increases were observed in red blood cell count, hemoglobin, hematocrit, and white blood cell (WBC) and platelet counts. In regard to the magnitude of these changes (mean values), hemoglobin varied from 12.8 g to 13.5 g/dL, hematocrit from 40.6 to 42.6%, platelet counts from 297 to 320 × 10<sup>9</sup>/L, and WBC counts from 7.37 to 7.62 × 10<sup>9</sup>/L.<sup>4</sup>

In this issue of the *Brazilian Journal of Hematology and Hemotherapy*, Lima-Oliveira et al.<sup>5</sup> report the findings of a study performed in 19 healthy volunteers that aimed

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<sup>☆</sup> See paper by Lima-Oliveira et al. in *Rev Bras Hematol Hemoter.* 2017;39(2):127-32.

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to evaluate the impact of posture changes in CBC values, with focus on platelet and differential WBC count. Similar results were obtained concerning red blood cell parameters and platelet counts compared to the 1988 study. In addition, increases in neutrophil and lymphocyte counts were also demonstrated, with mean values in supine and standing positions varying from  $3.2$  to  $3.7 \times 10^9/L$  for neutrophil count and from  $1.7$  to  $1.9 \times 10^9/L$  for lymphocyte count. These results confirm and extend previous reports,<sup>3,4,6,7</sup> supporting the importance of standardizing sample collection for laboratory evaluations, as already established by most CBC collection guidelines. While the claim for clinical significance of the changes reported by Lima-Oliveira et al. can certainly be disputed, one should consider that the magnitude of these changes can also be influenced by other variables such as temperature, previous exercise, tourniquet use and even fainting during sample collection, as recently reviewed.<sup>8</sup> Accordingly, the final bias caused by posture variations could be even higher in the real world. Even more important, the results of Fawcett and Wynn showing that posture-induced changes in total plasma volume tend to be higher in patients than in healthy individuals highlights the importance of considering these variations in our clinical evaluations. As a specialty dealing with patients whose Starling equation rarely equals zero and whose samples are frequently obtained under very diverse conditions, knowledge that up to 30% of variations in total plasma volume can be attributed solely to lying down should certainly influence our posture and our reasoning during clinical evaluations.

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## Conflicts of interest

The author declares no conflicts of interest.

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