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USING DIAGNOSTIC AND MATHEMATICAL MODELS TO DETERMINE RED BLOOD CELL DESTRUCTION RESULTING FROM SPACE FLIGHT ANEMIA

Abstract

During the initial days in a microgravity environment, blood volume held in the extremities pools centrally and is eliminated from the body through increased urine output. This fluid shift increases the hematocrit and astronauts become temporarily polycythemic. The hematocrit level is then progressively restored possibly through neocytolysis in which younger red blood cells (RBC) are selectively destroyed as a result of decreased erythropoietin (EPO) levels (Cell Physiol Biochem: 15:245-250, 2005). Results from the WISE study (J Appl Physiol: 107:540-548, 2009) confirmed the initial polycythemia with 60 days of head down bed rest (used as a model for microgravity). EPO levels remained relatively unchanged, while an increase in reticulocyte counts was measured in the study. These findings raised the hypothesis that increased reticulocyte production could occur in addition to increased destruction mediated through ineffective hematopoiesis. The objective of our study was to develop diagnostic and mathematical models to quantify RBC destruction and production. The diagnostic models will approximate RBC destruction by measuring endogenous carbon monoxide production, haptoglobin and urobilin/stercobilin levels. The mathematical model was developed using a linear piece-wise function that incorporates normal RBC turnover and reticulocyte production during bed-rest. By comparing the predicted RBC changes from the model with measured changes as determined using the aforementioned biochemical indices, we will gain additional insight into the role of ineffective hematopoiesis and neocytolysis in space flight anemia. Furthermore, the models can estimate the number of RBCs destroyed, which can be used to determine EPO dosages. EPO can then be administered to astronauts during flight who are returning to earth from a long-term mission in order to prevent anemia upon arrival.