Blood flow through microvascular networks has been shown to change, oscillate, and even reverse direction without biological control. In order to study this phenomenon, we investigate a model of blood flow through small vessels. Blood flowing through small vessels exhibits rheological properties such as the Fåhraeus-Lindqvist effect, which describes the viscosity of blood, and plasma skimming, which governs the separation of red blood cells at diverging nodes. We define a node to be the intersection of exactly three blood vessels, and a network to be the union of two or more nodes. To help understand large complex networks consisting of hundreds of vessels, we begin by studying a simple three node network. Using a variety of analytical and computational tools, we develop methods to find the equilibrium solutions that a given configuration of the three node network can support and the stability of each of these solutions. Our results will be used to design in vitro experiments. (Received September 16, 2008)