The pathogenesis of many congenital cardiovascular diseases involves abnormal flow within the embryonic vasculature, resulting either from heart malformations or from defects in the vasculature itself. Extensive genetic and genomic analysis in the mouse and in zebrafish has led to the identification of an array of mutations that result in cardiovascular defects during embryogenesis. Using rapid confocal microscopy we have been developing quantitative tools to analyze fluid and structural motions to better understand how circulation is initiated during embryogenesis and how endothelial cells respond to varying flows. Our studies show that shear stress levels in the developing mouse yolk sac are within levels known to induce the expression of developmentally relevant genes and that the circulation of erythroblasts is necessary for vascular remodeling to occur. In a related series of experiments, we have been characterizing the contractions of the embryonic heart to determine how blood flow changes as the heart loops and chambers emerge. Using the methods we have established, we are able to characterize the very first heart beats in the embryo, providing vital information about the initiation of embryonic circulation and defects encountered in mutant phenotypes.