Congenital Heart Disease (CHD) occurs in about 1% (40,000) newborn babies each year in the United States alone. About 10.9% (960) of whom suffer from Hypoplastic Left Heart Syndrome (HLHS) a subset of CHD where children are born with a single-ventricle (SV). A series of three surgeries are carried out to correct HLHS culminating in the Fontan procedure where venous flow returns passively to the lungs. The current configuration for the Fontan results in elevated central venous pressure (IVC pressure), inadequate ventricular preload, and elevated Pulmonary Vascular Resistance leading to a barrage of disease. To alleviate these complications, a ‘self-powered’ Fontan is suggested where an Injection Jet Shunt (IJS) emanating from the aorta and anastomosed to the pulmonary arteries. The IJS attempts to reduce the central venous pressure, increase preload, and aid in pulmonary arterial growth by entraining the flow with a high energy source provided by the aorta. Previous computational studies on this concept with rigid vessel walls show mild success, but not enough to be clinically relevant. It is hypothesized that vessel wall deformation may play an important role in enhancing the jet effect to provide a larger exit area for the flow to diffuse while also being more physiologically accurate. A multiscale 0D–3D tightly coupled Computational Fluid Dynamics (CFD) with Fluid-Structure Interaction (FSI) model is developed to investigate the efficacy of the proposed ‘self-powered’ Fontan modification. Several runs are made varying the PVR to investigate the sensitivity of IVC pressure on PVR. IVC pressure decreased by 2.41 mmHg while the rigid wall study decreased the IVC pressure by 2.88 mmHg. It is shown that IVC pressure is highly sensitive to changes in PVR and modifications to the Fontan procedure should target aiding pulmonary arterial growth as it is the main indicator of Fontan success.