The processes of cell proliferation, differentiation, migration, and self-organization during human development are governed by dynamic, spatially and temporally varying morphogen signals. Analogous tissue patterns emerge spontaneously in human embryonic stem cell (hESC) models for gastrulation, but mechanistic insight into this self-organization is limited by a lack of molecular methods to precisely control morphogen signal dynamics. Here we combine optogenetic stimulation and single-cell imaging approaches to study self-organization of human pluripotent stem cells (hPSCs). Precise control of morphogen signal dynamics, achieved through activation of canonical Wnt/β-catenin signaling over a broad high dynamic range (>500-fold) using an optoWnt optogenetic system, drove broad transcriptional changes and mesendoderm differentiation of hPSCs at high efficiency (>95% cells). Furthermore, activating Wnt signaling in subpopulations of hPSCs in 2D and 3D cultures induced cell self-organization and morphogenesis reminiscent of human gastrulation, including changes in cell migration and epithelial to mesenchymal transition. With vinyl masks, we also induced spatial and temporal control of Wnt signaling in 2D, leading to native-like cardiac patterning. Our findings thus reveal an instructive role for Wnt in directing cell patterning in this hPSC model for gastrulation and cardiac development.