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Marangoni-like tissue flows contribute to symmetry breaking of embryonic organoids

During development, embryonic tissues self-organize to achieve spatial organization and shape. While this process has been widely described through bio-chemical signaling, the role of active tissue mechanics during embryo morphogenesis remains poorly explored. In particular, we do not yet understand the possible role of mechanics in the emergence of the body plan, when the main axes and symmetries are set in the early embryo. In this work, we address this question using self-organized 3D stem cell aggregates recapitulating embryo-like development in-vitro. Once cell differentiation is activated, these embryonic organoids exhibit spontaneous elongation and symmetry breaking with respect to molecules characterizing primary embryonic tissues. We show that this symmetry breaking is accompanied by long-range tissue flows that contribute to the aggregate polarization. We develop a mode decomposition analysis showing that these flows exhibit a dominant Marangoni-like recirculation pattern. In order to understand how such flows can robustly emerge, we build a minimal continuum model assuming that large-scale tissue stresses are controlled by key molecule concentrations within the tissue. Our simulations are able to reproduce the dominant flow pattern based on experimentally measured concentration fields. Our work emphasizes the importance of advection for tissue organization in embryonic organoids.

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