When things go wrong: A breakdown of breakdowns in optimally resilient vascular networks

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Life above a certain size relies on a circulatory system for oxygen and nutrient delivery; without it, no complex animal would exceed a few millimeters. As a result, plants, animals and fungi have developed circulatory systems of striking complexity. Typically, these systems have to satisfy competing demands to operate efficiently and robustly while confronted with an ever-changing environment [1,2]. The architecture of these networks, as defined by the topology and edge weights, determines how efficiently the networks perform their function and represents a trade-off between optimizing power dissipation, construction cost, and tolerance to damage [3,4].

In this work we delve further in the vascular network's tolerance to damage. Loosely modeling ischemic strokes, we quantify the extent of functional disruption a vascular network undergoes when a vessel is occluded. We study how the topology and hierarchy of the network can influence the extent of the disruption. We find that a highly conducting vessel establishes a region around it where, if an occlusion where to occur, the effects on the global flow profile are minimized. We discuss what these results mean for the design of optimally tolerant vascular networks.

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