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Pulse propagation in compliant complex networks.

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The primary role of vascular networks is to facilitate the efficient flow of nutrients where needed in the organism. A power source is necessary to overcome energy losses due to the viscosity of the fluid and maintain the flow. In animals, this is achieved via the periodic pumping of the heart, and the peristaltic pressure waves of the vessels. The pressure pulses created this way interact with the compliant, elastic vessels and propagate through the network, creating rich dynamics. We use an electrical circuit analogue to model the elastic vessels as transmission lines, and discover a robust scaling law between energy dissipation and speed of mechanical information transmission, via pressure pulse propagation. Pressure pulse propagation also plays an important role in the function of the venous and lymphatic system, which have to transmit flow against pressure gradients. Here, we discuss how traveling pulses in conjunction with properly placed valves overcome these gradients to achieve flow, and demonstrate how the coupling of the valve to the elastic vessel where it is embedded affects performance. These phenomena highlight the importance of the interactions between the fluid flow and the soft matter that surrounds it, in achieving biological function and optimizing fitness.