Chapter 8

Conclusion

This work introduced a new an innovative Impedance Pump (IP) design, the Multilayer Impedance Pump (MIP), where a thick internal gelatin layer is used to amplify elastic waves and that allow small excitation only. By exploring flow and structure response to frequencies of excitation, the resonance nature of the pump has been demonstrated. Higher flow and greater wall motion are achieved when the pump is excited around its natural frequency. Energy transmission is also more efficient at resonance, resulting in a higher efficiency for the pump excited at the resonance frequency.

Because the MIP is directly inspired from the embryonic heart structure, the use of the MIP model has allowed shedding light on nature's optimized design. First, by comparing the multilayer tube for two pumping modes (peristalsis and impedance), impedance pumping revealed to be more energetically advantageous with respect to its peristalsis equivalent. This result brings an additional piece of evidence that the embryonic heart may use elasticity and impedance mismatch to drive unidirectionaly the flow, and not a sequence of peristaltic contractions as previously thought. Second, by comparing two impedance pumps (with and without gelatin-like internal layer), the added gelatin layer has been found to have a mechanical benefit in terms of exit flow. By extension, cardiac jelly may have a role in enhancing flow in the embryonic heart.

Thanks to its unique wall structure, the MIP reveals itself an adequate pumping device for biomedical applications. To test the MIP as an intra aortic pump, a Windkessel boundary condition that creates physiological pressure and flow waveforms has been proposed. Future work will focus on a model of MIP model in the descending adult aorta to show its potential for cardiovascular applications.