# The *in vitro* artery: an instrumented platform for quantitative vascular research

**Elizabeth E. Antoine**[1], **Abdul I. Barakat**[1]

[1] Hydrodynamics Laboratory (LadHyX), Ecole Polytechnique, Palaiseau, France

elizabeth.antoine@ladhyx.polytechnique.fr,
barakat@ladhyx.polytechnique.fr

Although vascular disease is a leading cause of mortality, *in vitro* tools for controlled, quantitative studies of vascular biological processes in an environment that reflects physiological complexity remain limited. Computational models provide invaluable insight regarding the dynamics of cardiovascular disease and inform stent design strategies; however, the availability of in vitro devices for validation of numerical work remains critically limited [1, 2].

We have developed a novel *in vitro* artery that allows deployment of endovascular devices including stents, quantitative real-time tracking of cellular responses, and detailed measurement of flow velocity and lumenal shear stress using particle image velocimetry [3]. The wall of the *in vitro* artery consists of an annular collagen hydrogel containing smooth muscle cells (SMCs) and whose lumenal surface is lined with a monolayer of endothelial cells (ECs). The system has *in vivo* dimensions and physiological flow conditions and allows automated high-resolution live imaging of both SMCs and ECs. To demonstrate proof-of-concept, we imaged and quantified EC wound healing, SMC motility, and altered shear stresses on the endothelium after deployment of a coronary stent. In addition, we have adapted the algorithms developed for quantification of the *in vitro* artery for use with similar but simpler 2D experimental systems.

The *in vitro* artery and accompanying post-processing tools provide a unique platform suited for a broad array of research applications. For example, quantitative data obtained from the *in vitro* artery can inform *in silico* models of cellular migration, wound healing, and cardiovascular disease progression. Wide-scale adoption of this system promises to enhance our understanding of important biological events affecting endovascular device performance and to reduce dependence on animal studies.

**Keywords:** endothelial wound healing; *in vitro* artery; stent; shear stress; collagen hydrogel; quantitative cellular imaging

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## REFERENCES

[1] S. Morlacchi, F. Migliavacca, Modeling stented coronary arteries: where we are, where to go, *Annals of Biomedical Engineering*, **41**(7), pp. 1428-1444, 2013.

[2] K. Kolandaivelu, B. Leiden, E. Edelman, Predicting response to endovascular therapies: dissecting the roles of local lesion complexity, systemic comorbidity, and clinical uncertainty, *Journal of Biomechanics*, **47**(4), pp. 908-921, 2014.

[3] E. Antoine, F. Cornat, A.I.Barakat, The stentable *in vitro* artery: an instrumented platform for endovascular device development and optimization, *Royal Society Interface*, **In Press**.