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One-Dimensional Blood Flow with Discontinuous Properties and Transport: Numerical Schemes and Treatment of Junctions

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In this work we focus our attention on physical situations of medical interest in which certain properties that characterize compliant vessels change rapidly in space, for example after the insertion of stents in arteries or in veins due to a surgical procedure. We consider the one-dimensional blood flow model with discontinuous mechanical and geometrical properties, as well as passive scalar transport, proposed in [1], then we present a second order DOT Riemann solver, proposing an integration path that incorporates the passive scalar, completing the one proposed in [2], and proving the well-balanced properties of the resulting numerical scheme for stationary solutions. By using suitable test problems for which exact solutions are available, we assess the well-balanced properties of the scheme, its capacity to provide accurate solutions in challenging flow conditions and its accuracy [3]. Finally we formalize the computation of coupling conditions for vessels with passive scalar transport in the context of a Riemann problem at a junction. We conclude by presenting an application of clinical interest regarding the propagation of a passive scalar in a network of coronary vessels simulating the passage of contrast agent during a cardiac Computed Tomography and discuss similarities of obtained profiles with a clinical index called Transluminal Attenuation Gradient.

References

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