Benchmark dataset for validating computational fluid dynamic (CFD) simulation of blood flow through generalized medical device geometries

Catalog of Regulatory Science Tools to Help Assess New Medical Devices

Technical Description

The tool provides validation data (pressure and velocity field) obtained from inter-laboratory bench experiments within generic and simplified i) Nozzle and ii) Blood pump geometries. Modelers can use the pressure and velocity validation data to perform early-stage validation of their computational fluid dynamics (CFD) model/software before performing any device-specific verification, validation and credibility assessment.

The validation data was obtained using particle image velocimetry (PIV) at three independent laboratories, details of which are provided in Section 2.0 of Hariharan et al. [DOI: 10.1115/1.4003440]

We have provided full technical description of the test devices, flow conditions, fluid properties, access to CAD models, and the validation experimental data here
https://ncihub.org/wiki/FDA_CFD to ensure that modelers use appropriate input parameters to mimic the experiments, Details about the flow conditions and fluid properties for the nozzle and pump geometries are also provided in section 2.0 and Methods section of Hariharan et al. 2009 [DOI: 10.1115/1.4003440] and Hariharan et al. 2018 [https://doi.org/10.1007/s13239-018-00378-y], respectively.

Intended Purpose

The benchmark dataset can be used as an early-stage validation of computational fluid dynamic (CFD) models simulating blood flow through blood contacting devices with geometry and flow features comparable to the benchmark nozzle and pump geometries. The early-stage validation is limited to velocity and pressure data within the benchmark geometries. Please note that additional device-specific verification and validation may be required to analyze the overall credibility of the CFD model.

Testing

This inter-laboratory generated benchmark dataset has been extensively used by academia, medical device industry, and third party laboratories (see below)as a verification and validation tool.

List of organizations that used the benchmark geometry and/or dataset:

ASME V&V 40 standard, Livermore Software Technology, Dassault Systèmes, Ansys Inc., Pointwise, Institute for Implant Technology and Biomaterials, University of Magdeburg, Germany, Mississippi State University, University of Twente, Netherlands, University of the Balearic Islands, Palma, Spain, University of Montpellier, France, Imperial College London, Universiti Teknologi Malaysia, Royal Institute of technology, University of Munich, University of Ljubljana, Soochow University, China, Veryst Systems, Universidad Politécnica de Madrid, Universite de Strasbourg, Washington Univ. St. Louis, Purdue University, University of Sheffield, University of Rostock, Lehigh University, University of Houston, University of Oklahoma, University of Tehran, Enmodes GmbH, Aachen, Germany, Koc University

Please see https://ncihub.org/wiki/FDA_CFD/ComputationalRoundRobin1Nozzle/citations for the links to external technical articles that were published based on this tool (as of Dec 2021).

Limitations

Validation using this tool is limited to velocity and pressure data within the benchmark FDA nozzle and FDA blood pump geometries. Device-specific verification and validation will be required to analyze the overall credibility of the CFD model.

Supporting Documentation

Full technical description of the test devices, access to CAD models, test conditions, and experimental data are provided here

- https://ncihub.org/wiki/FDA_CFD

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Tool Reference

In addition to citing relevant publications please reference the use of this tool using DOI: 10.5281/zenodo.6629049

For more information:

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