Martin R. Pfaller, Ph.D.

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Research Vision

My vision is to develop personalized computational models to lessen the consequences of heart tissue injury and translate these discoveries into their clinical applications. My future research program will bridge the modeling of long-term heart function with cellular experiments and medical imaging. This connection can transform the treatment of heart diseases by predicting a disease's course and optimal treatment at the time of diagnosis.

Academic Training

2022 **Postdoctoral Scholar**, *Pediatrics – Cardiology*, Stanford University
Focus: Cardiovascular Fluid Dynamics, Growth and Remodeling
PIs: Alison L. Marsden, Jay D. Humphrey

2019 **Ph.D.**, *Mechanical Engineering*, TU Munich (Technical University of Munich, Germany)
Thesis: Predictive Computational Modeling of Patient-Specific Cardiac Mechanics
PIs: Wolfgang A. Wall, Cristóbal Bertoglio

2013 **M.Sc.**, *Mechanical Engineering*, TU Munich
Thesis: Instabilities During Mucosal Folding Induced by Volumetric Growth
PIs: Ellen Kuhl, Wolfgang A. Wall

2012 **B.Sc.**, *Mechanical Engineering*, TU Munich
Thesis: Skew Maximum-Entropy Prior Functions for Convection-Diffusion Problems
PI: Wolfgang A. Wall

Honors and Awards

2022 – 2027 **NIH Pathway to Independence Award (K99/R00)**, National Heart, Lung, and Blood Institute
Award for mentored and faculty research on computational modeling of heart failure, $1,071,432 (summary)

2022 – 2024 **Instructor K Award Support**, Stanford Maternal and Child Health Research Institute
Supplement to research expenses of NIH K99 award, $100,000

2022 **Travel Awards**, Additional Ventures & Stanford Cardiovascular Institute

2019 **Dissertation Award**, Association of German Engineers (VDI)

2016 & 2017 **Awards for Outstanding Teaching**, *Student Council Mechanical Engineering*, TU Munich

2013 **Exchange Scholarships**, German Academic Exchange Service (DAAD) & Erich Müller-Stiftung

Research Experience

Since 2022 **Instructor**, *Pediatrics – Cardiology*, Stanford University
PI on NIH K99 award "Computational Stability Analysis to Predict Heart Failure after Myocardial Infarction"

2019 – 2022 **Postdoctoral Scholar**, *Pediatrics – Cardiology*, Stanford University
- Co-mentored eleven undergraduate and graduate students
- Lead open-source software development
- Generated reduced-order models for fast yet accurate cardiovascular fluid dynamics
- Implemented methods for fluid-solid-growth interaction in blood vessels

2014 – 2018 **Research Assistant**, *Mechanical Engineering*, TU Munich
- Mentored ten undergraduate and graduate thesis projects
- Built the new area of cardiac mechanics within the research group
- Established collaborations with scientists from other groups
- Developed and validated a computational heart model with magnetic resonance imaging

2013 **Visiting Student Researcher**, *Mechanical Engineering*, Stanford University
Validated a computational model for airway wall growth with mathematical models

Mentored students, * corresponding

Journal Articles – Submitted

S3. Pegolotti L,* **Pfaller MR**, Rubio NL, Ding K, Brugarolas Brufau R, Darve E, Marsden AL. Learning Reduced-Order Models for Cardiovascular Simulations with Graph Neural Networks, 2023. arXiv

S2. Nair PJ,* **Pfaller MR**, Dual SA, Loecher M, McElhinney DB, Ennis DB, Marsden AL. Hemodynamics in Patients with Aortic Coarctation: A Comparison of in vivo 4D-Flow MRI and FSI Simulation, 2023. bioRxiv

S1. Gebauer AM,* **Pfaller MR**, Braeu FA, Cyron CJ, Wall WA. A homogenized constrained mixture model of cardiac growth and remodeling: Analyzing mechanobiological stability and reversal, 2023. arXiv

Journal Articles – Accepted

A13. Schwarz EL, Pegolotti L, **Pfaller MR**, Marsden AL.* Beyond CFD: Emerging Methodologies for Predictive Simulation in Cardiovascular Health and Disease, *Biophysics Reviews*, 2023. DOI

A12. Pham J,* Wyetzner S, **Pfaller MR**, Parker DW, James DL, Marsden AL. svMorph: Interactive geometry-editing tools for virtual patient-specific vascular anatomies, *Journal of Biomechanical Engineering*, 2023. DOI

A11. **Pfaller MR**,* Pham J, Verma A, Pegolotti L, Wilson NM, Parker DW, Yang W, Marsden AL. Automated generation of 0D and 1D reduced-order models of patient-specific blood flow, *International Journal for Numerical Methods in Biomedical Engineering*, 2022 (selected for October 2022 journal cover). DOI

A10. Anbazhakan S, Rios Coronado PE, Sy-Quia ANL, Seow A, Hands AM, Zhao M, Dong ML, **Pfaller MR**, Raftrey BC, Cook CK, Bernstein D, Nieman K, Paşca AM, Marsden AL,* Red-Horse K.* Blood flow modeling reveals improved collateral artery performance during mammalian heart regeneration, *Nature Cardiovascular Research*, 2022. DOI

A9. **Pfaller MR**,* Pham J, Wilson NM, Parker DW, Marsden AL. On the periodicity of cardiovascular fluid dynamics simulations, *Annals of Biomedical Engineering*, 2021. DOI

A8. Pegolotti L,* **Pfaller MR**, Marsden AL, Deparis S. Model order reduction of flow based on a modular geometrical approximation of blood vessels, *Computer Methods in Applied Mechanics and Engineering*, 2021. DOI

A7. **Pfaller MR**,* Cruz Varona M, Lang J, Bertoglio C, Wall WA. Parametric model order reduction and its application to inverse analysis of large nonlinear coupled cardiac problems, *International Journal for Numerical Methods in Biomedical Engineering*, 2020 (featured in Top Articles in 2020-2021). DOI

A6. Pivovarov D, Willner K, Steinmann P, Brumme S, Müller M, Srisupattarawanit T, Ostermeyer GP, Henning C, Ricken T, Kastian S, Reese S, Moser D, Grasedyck L, Biehler J, **Pfaller M**, Wall W, Kohlsche T, von Estorff O, Gruhlke R, Eigel M, Ehre M, Papaioannou I, Straub D, Leyendecker S.* Challenges of order reduction techniques for problems involving polymorphic uncertainty, *GAMM Mitteilungen*, 2019. DOI

A5. Hörmann JM, **Pfaller MR**, Avena L, Bertoglio C,* Wall WA. Automatic estimation of atrial fiber orientations for patient-specific modeling of cardiac electromechanics using image-registration, *International Journal for Numerical Methods in Biomedical Engineering*, 2019. DOI

A4. **Pfaller MR**,* Hörmann JM, Weigl M, Nagler A, Chabiniok R, Bertoglio C, Wall WA. The importance of the pericardium for cardiac biomechanics: From physiology to computational modeling, *Biomechanics and Modeling in Mechanobiology*, 2019. DOI

A3. Hörmann JM, Bertoglio C, Kronbichler M,* **Pfaller MR**, Chabiniok R, Wall WA. An adaptive hybridizable discontinuous Galerkin approach for cardiac electrophysiology, *International Journal for Numerical Methods in Biomedical Engineering*, 2018. DOI

A2. Hörmann JM, Bertoglio C,* Nagler A, **Pfaller MR**, Bourier F, Hadamitzky M, Deisenhofer I, Wall WA. Multiphysics modeling of the atrial systole under standard ablation strategies, *Cardiovascular Engineering and Technology*, 2017. DOI

A1. Eskandari M, **Pfaller MR**, Kuhl E.* On the role of mechanics in chronic lung disease, *Materials*, 2013. DOI

Book Chapter – Submitted

B1. **Pfaller MR**, Pegolotti L, Pham J, Rubio NL, Marsden AL. Reduced Order Modeling of Cardiovascular Hemodynamics, *Biomechanics of the Aorta: Modelling for Patient Care*, edited by C Gasser, S Avril, J Elefteriades, 2022.

Conference Proceedings and Abstracts

P9. **Pfaller MR**,* Latorre M, Schwarz EL, Szafron JM, Humphrey JD, Marsden AL. A Computational Model for Cardiovascular Fluid-Solid-Growth Interaction, *Additional Ventures Single Ventricle Investigator Meeting*, Baltimore, MD, 2022.

P8. **Pfaller MR**,* Latorre M, Schwarz EL, Szafron JM, Humphrey JD, Marsden AL. A Computational Model for Cardiovascular Fluid-Solid-Growth Interaction, *7th International Conference on Computational and Mathematical Biomedical Engineering – CMBE*, P Nithiarasu and C Vergara (Eds.), Milan, Italy, 2022.

P7. **Pfaller MR**,* Lan IS, Wilson NM, Parker DW, Marsden AL. The Vascular Model Repository and SimVascular, *Society for Cardiovascular Magnetic Resonance (SCMR) Virtual Scientific Sessions*, online, 2021.

P6. **Pfaller MR**,* Hörmann JM, Weigl M, Nagler A, Chabiniok R, Bertoglio C, Wall WA. Physiology, computational modeling, and impact of pericardial boundary conditions, *Modelling the Cardiac Function*, online, 2020.

P5. **Pfaller MR**,* Wilson NM, Yang W, Parker DW, Marsden AL. Automated reduced-order modeling for a repository of large-scale patient-specific blood flow simulations, *Virtual Physiological Human Conference*, online, 2020.

P4. **Pfaller MR**,* Wilson NM, Yang W, Parker DW, Marsden AL. Automatic creation of one-dimensional flow models from three-dimensional anatomical geometries, *Summer Biomechanics, Bioengineering, and Biotransport Conference*, online, 2020.

P3. **Pfaller MR**,* Lang J, Cruz Varona M, Biehler J, Bertoglio C, Wall WA. Parametric model order reduction using POD for coupled nonlinear cardiac mechanics, *6th European Conference on Computational Mechancis – ECCM-ECFD*, Glasgow, United Kingdom, 2018.

P2. **Pfaller MR**,* Nagler A, Hörmann JM, Weigl M, Bertoglio C, Kozerke S, Stoeck CT, Wall WA. Influence of Fiber Architecture and Pericardial Boundary Conditions on Cardiac Mechanics Simulations, *7th European Congress on Computational Methods in Applied Sciences and Engineering – ECCOMAS*, Crete Island, Greece, 2016.

P1. **Pfaller MR**,* Nagler A, Bertoglio C, Hirschvogel M, Wall WA. Pericardial Boundary Conditions for Cardiac Mechanics Simulations, *4th International Conference on Computational and Mathematical Biomedical Engineering – CMBE*, P Nithiarasu and E Budyn (Eds.), Cachan, France, 2015.

Software Projects and Repositories

Development, maintenance, and administration of open-source scientific software projects and repositories

- Vascular Model Repository: Curated subject-specific fluid dynamics models of blood vessels
- SimVacsular: Cardiovascular fluid dynamics simulation suite with a graphical user interface
- svOneDSolver: One-dimensional fluid dynamics solver for a network of tube-like blood vessels
- svZeroDSolver: Zero-dimensional fluid dynamics solver for lumped-parameter networks of blood vessels
- svFSI: Three-dimensional finite element solver for electrophysiology, structure, and fluid dynamics

Teaching Experience

2020 – 2023 **Bioengineering**, *Guest lecturer*
Taught selected lectures in several courses
- BIOE 285 – Computational Modeling in the Cardiovascular System
- BIOE 390 – Introduction to Bioengineering Research
- BIOE 301C – Diagnostic Devices Lab

2021 **Nonlinear Continuum Mechanics**, *Instructor*
Created and taught a mini-course for lab-members

2021 **SimVascular software workshop**, *Instructor*, SB3C conference
Taught a section on reduced-order modeling in our open-source software

2017 – 2018 **Solid Mechanics 3 – Dynamics**, *Teaching assistant*
Organized online course and lecture recordings, transitioned teaching responsibilities

2017 **Solid Mechanics 2 – Elastostatics**, *Head teaching assistant*
Transitioned to teaching with five teaching assistants, introduced computer-based exam reviews

2016 – 2017 **Solid Mechanics 1 – Statics**, *Head teaching assistant*
Taught 703 undergraduate students weekly, supervised 23 section leaders, introduced lecture recordings

2016 **Visualization in Solid Mechanics**, *Instructor*
Mentored teams of highly talented students developing their own teaching software (e.g. Google Play)

2015 – 2016 **Solid Mechanics 3 – Dynamics**, *Head teaching assistant*
Taught 610 undergraduate students weekly, supervised 17 section leaders, introduced live quizzes

2015 **Solid Mechanics 2 – Elastostatics**, *Teaching assistant*
Created video tutorials. See e.g. tutorial on Mohr's Circle on YouTube (55k views)

2014 – 2015 **Solid Mechanics 1 – Statics**, *Teaching assistant*
Created video tutorials. See e.g. tutorial on influence lines on YouTube (10k views)

Work Experience

2019 – 2020 **Research Consultant**, Ablacon
Devised simulation tools to diagnose atrial fibrillation and guide catheter ablation surgery

2012 – 2013 **Student Trainee**, *Research and Development*, BMW
- Preformed stress analysis calculations for electric motors
- Enabled a fast prototyping process by giving design recommendations based on simulations

2011 – 2012 **Student Trainee**, *Corporate Technology*, Siemens
- Implemented software for communication between various finite element solvers
- Reduced costs for software licenses by using open-source software for the simulation process

2009 – 2011 **Undergraduate Teaching Assistant**, *Mechanical Engineering*, TU Munich
- Gained a deep understanding of mechanical engineering core subjects by teaching others
- Taught a class of non-engineering undergraduate students in solid mechanics

Professional Service

- **Grant Review**: Dutch Research Council (NWO) – Vidi Program
- **Program Review**: Stanford Maternal & Child Health Research Institute Postdoctoral Fellowship Mock Review, Stanford Cardiovascular Institute Summer Research Program
- **Journal Peer Review**: Bioengineering, Cardiovascular Engineering and Technology, European Radiology, International Journal for Numerical Methods in Biomedical Engineering, Medical Image Analysis

Outreach

Performed in "science slams," giving entertaining short talks about my scientific research to a general audience

2020 **Participant**, invited by the German Academic International Network (YouTube)

2017 **Winner**, invited by the Mechanical Engineering Student Council, TU Munich

Student Research Mentoring

Doctoral candidates

Since 2023	**Anjini Chandra**, Fluid-solid-growth interaction in tissue-engineered vascular grafts.	*Stanford*
2022	**Faiza Tabassum**, Reduced-order modeling of blood flow using the Port Hamiltonian method.	*TU Munich*
Since 2021	**Erica Schwarz**, Computational modeling of tissue-engineered vascular grafts.	*Stanford*
Since 2021	**Priya Nair**, Simulation-based treatment planning for patients with aortic coarctations.	*Stanford*
Since 2020	**Janina Datz**, Mechanical effects of coronary in-stent restenosis.	*TU Munich*
Since 2020	**Amadeus Gebauer**, Multi-scale modeling of cardiac growth and remodeling.	*TU Munich*
Since 2020	**Natalia Rubio**, Machine learning-enhanced reduced-order models of blood flow.	*Stanford*
Since 2020	**Numì Sveinsson**, Automatic segmentation of blood vessels using convolutional neural networks.	*UC Berkeley*
2020	**Luca Pegolotti**, Model order reduction of flow based on a modular geometrical approximation of blood vessels.	*EPFL*
2019 – 2023	**Jonathan Pham**, Interactive geometry-editing tools for virtual patient-specific vascular anatomies.	*Stanford*

Master's theses (six months)

Since 2022	**Jakob Richter**, Multi-fidelity boundary condition tuning for cardiovascular fluid dynamics simulations under uncertainty.	*Stanford*
2019 - 2020	**Amadeus Gebauer**, Growth and remodeling for cardiac mechanics simulations.	*TU Munich*
2018	**Magnus Mechler**, Projection-based hyper-reduction for 3D-0D coupled cardiovascular mechanics.	*TU Munich*
2017	**Johannes Lang**, Projection-based parametric model order reduction for 3D-0D coupled cardiac mechanics.	*TU Munich*
2015	**Jonas Schollenberger**, A lumped parameter model of cerebral blood flow regulation: Applications to simulation of carotid endarterectomy.	*University of Michigan*

Semester theses (three months)

2018	**Maximilian Gruber**, Electrophysiological simulation of atrial fibrillation.	*TU Munich*
2017	**Miriam Bastian**, Influence of pericardial boundary conditions on systolic cardiac function in mechanical simulations.	*TU Munich*
2016	**Sebastian Kaltenbach**, Reduced-order mathematical modeling of cardiac growth and remodeling.	*TU Munich*

Bachelor's theses (three months)

2018	**Lukas Küchle**, Implementation and verification of a Gauss-point-based fiber formulation.	*TU Munich*
2016	**Janina Datz**, Estimation of cardiac muscle fiber architecture from diffusion-weighted magnetic resonance imaging.	*TU Munich*
2015	**Christina Insam**, A reduced-order model of left ventricular mechanics using a prolate spheroid geometry.	*TU Munich*

Student projects

2020 – 2021	**Elena Martinez**, Modeling blood pressure losses over blood vessel junctions, *Summer Undergraduate Research Fellowship (SURF) and McNair Scholar*.	*Stanford*
2016 – 2017	**Raphael Gebhart**, Live quizzes for Solid Mechanics lectures.	*TU Munich*
2016	**Martina Weigl**, Segmentation of a four-chamber cardiac geometry.	*TU Munich*
2015 – 2016	**Martina Weigl**, Implementation of a Laplace fiber lifting class in Python.	*TU Munich*