Karoline-Marie Bornemann, PhD

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Department of Pediatrics (Cardiology), Stanford University

I am a **computational biomedical engineer** specialized in **cardiovascular fluid dynamics** with a **background in aerospace engineering**. My research focuses on the computational modeling of **heart valves** using **fluid-structure interaction simulations**. My **long-term research goal** is to **use numerical modeling** to **understand complex cardiovascular pathophysiology** and **answer relevant clinical questions**. In my previous research, I investigated the onset of turbulence past bioprosthetic valve prostheses in adults. Given the significant lack of cardiovascular research in pediatrics compared to adults, I decided to apply my acquired knowledge in the modeling of valve prostheses to tackle highly complex and patient-specific problems of congenital heart diseases. At Stanford University, a world-class leader in pediatric cardiovascular disease and surgery, I apply my obtained skill set to the computational modeling of congenital valve diseases and valve repair within an interdisciplinary team combining the individual strengths of both engineers and clinicians. My research **differs from the mainstream** as I use my **strong fundamental background in aerospace engineering** to **bridge the two worlds** of **highly sophisticated computational simulations** and **daily clinical practice** guided by the **mission to improve children's health**.

EDUCATION

PhD in Biomedical Engineering – summa cum laude 10/2024
ARTORG Center for Biomedical Engineering Research, University of Bern, Switzerland

Diplom-Ingenieurin (Dipl.-Ing., equivalent to MSc.) 09/2020
Mechanical Engineering with specialization Aerospace Engineering
Technical University Dresden, Germany

HONORS AND AWARDS

Graduate School for Biomedical and Cellular Sciences Best PhD Thesis of the Year 2024 06/2025
Best thesis award across Graduate School for Biomedical and Cellular Sciences, University of Bern

Winner of the Gallery of Fluid Motion Award 11/2024
American Physical Society (APS), Division of Fluid Mechanics

UniBE Short Travel Grant for (Post)Docs 04/2024
University of Bern

Best poster award in the category 'Pathology, Mechanisms and Outcomes' 02/2024
Heart Valve Society (HVS)

PROMOS International Scholarship 04/2019
German Academic Exchange Service (DAAD)

RESEARCH EXPERIENCE

Postdoctoral Scholar 05/2025 - now
Stanford University, USA
Department of Pediatrics, Division of Pediatric Cardiology
PIs: Alexander D. Kaiser, PhD | Alison L. Marsden, PhD
Clinical collaborator: Michael R. Ma, MD, Division Chief Pediatric Cardiac Surgery (Department of Cardiothoracic Surgery, Stanford University, USA)
Patient-specific computational modeling of a quadricuspid truncal valve in a neonate before and after truncus arteriosus repair

Postdoctoral Scholar 11/2024 - 03/2025
PhD Candidate 10/2020 - 10/2024
University of Bern, Switzerland
ARTORG Center for Biomedical Engineering Research
PIs: Dominik Obrist, PhD | Peter Schmid, PhD
Clinical collaborators: Caglayan Demirel, MD | Stefan Stortecky, MD (Department of Cardiology, University Hospital Bern, Switzerland)
Instability mechanisms leading to laminar-turbulent transition past bioprosthetic aortic valves

Visiting PhD Candidate 04/2024 - 06/2024
KTH Royal Institute of Technology, Sweden
FLOW Group, Department of Mechanics
PIs: Ardeshir Hanifi, PhD | Dan Henningson, PhD
Global stability analysis of three-dimensional flow fields past bioprosthetic aortic valves

Master Student 01/2020 – 09/2020
Technical University Dresden, Germany
Institute of Fluid Mechanics
PI: Jochen Fröhlich, PhD
Numerical investigation of turbulent flow over and through inhomogeneous vegetation canopies

Visiting Student 04/2019 – 10/2019
University of Melbourne, Australia
Department of Mechanical Engineering
PI: Richard Sandberg, PhD
Application of novel, machine-learning closure models for Reynolds averaged Navier Stokes calculations to an S-shaped diffuser

Intern and Working Student 10/2017 - 03/2018
IABG mbH, Germany
Investigation of vortex lift of two generic jet fighter aircrafts at high angles of attack

TEACHING, MENTORING AND SCIENCE OUTREACH TO SOCIETY

Science mentor for Stanford Science Penpals 10/2025 – now
Mentoring underserved middle school and high school students in the US and abroad
Stanford University

Interviewee for multiple newspaper articles showcasing my PhD research 2025
"20 Jahre GCB - Nachwuchsförderung in der Biomedizin (20 years of GCB – Fostering the new generation in biomedical sciences)", Interview for the GCB Best Thesis of the Year Award, 2025 LINK
"Scientists identify key risk factor for thrombosis after heart valve surgery", Swiss National Supercomputing Centre, 2025 LINK

Winner of the Gallery of Fluid Motion LINK 11/2024
Submitted a winning entry for the Gallery of Fluid Motion which aims to establish visual record of the aesthetic and science of contemporary fluid mechanics, shared with cross-disciplinary researchers and the general public
American Physical Society, Division of Fluid Dynamics

Instructor at Children's University Bern 03/2021 – 03/2025
Planned and held workshops for children of age 8 to 12 to gain inspiring insights into biomedical fields of science
University of Bern

Bachelor thesis supervisor for Guillaume Van Rossem 11/2023 – 02/2024
Thesis: The impact of neon-sinus on flow characteristics and sinus washout in transcatheter aortic heart valve thrombosis patients
University of Bern / ETH Zurich

Instructor at Night of Research, University of Bern 08/2021 – 08/2024
Co-organized the participation of the Cardiovascular Engineering lab at the annual Night of Research in Bern which aims to make current science topics and research questions accessible for the general public and children specifically
University of Bern

Teaching assistant and substitute lecturer for course 'Fluid Mechanics' 02/2021 – 01/2024
Taught weekly seminars, acted as substitute lecturer, corrected and graded weekly assignments, held office hours for graduate level students, graded final exams
University of Bern

Teaching assistant for course 'Fluid Mechanics' 04/2018 – 03/2019
Taught weekly seminars, created new course material, held office hours for graduate level students
Technical University Dresden

Teaching assistant for course 'Engineering Design and CAD' 10/2016 – 09/2017
Taught seminars twice per week, created an interactive student forum to foster discussion and collaboration, held office hours for undergraduate level students, graded assignments
Technical University Dresden

Volunteering tutor for "Studenten bilden Schüler e.V." 02/2016 – 03/2017
Offered free tutoring for children and young adults from low-income backgrounds within a voluntary organization aiming to fight and overcome educational inequality
Technical University Dresden

JOURNAL PAPERS – PUBLISHED

1. **Bornemann K-M**, Obrist D. Transition to turbulence past bioprosthetic aortic valves. *Physical Review Fluids.* 2025 DOI
2. **Bornemann K-M**, Obrist D. Leaflet fluttering changes laminar-turbulent transition mechanisms past bioprosthetic aortic valves. *Physics of Fluids*. 2025. DOI
3. **Bornemann K-M**, Jahren SE, Obrist D. The relation between aortic morphology and transcatheter aortic heart valve thrombosis: Particle tracing and platelet activation in larger aortic roots with and without neo-sinus. *Computers in Biology and Medicine*. 2024. DOI | PMID
4. **Bornemann K-M**, Obrist D. Instability mechanisms initiating laminar-turbulent transition past bioprosthetic aortic valves. *Journal of Fluid Mechanics*. 2024. DOI
5. Jahren SE, Vennemann B, **Bornemann K-M**, Rösgen T, Obrist D. Modes of leaflet fluttering: quantitative characterization of a bovine bioprosthetic heart valve. *Annals of Biomedical Engineering*. 2025. DOI
6. Jahren SE, Demirel C, **Bornemann K-M**, Corso P, Stortecky S, Obrist D. Altered blood flow due to larger aortic diameters in patients with transcatheter heart valve thrombosis. *APL Bioengineering*. 2023. DOI | PMID

JOURNAL PAPERS – UNDER REVIEW

1. **Bornemann K-M**, Moniripiri M, Henningson D, Obrist D, Schmid P, Hanifi A. Optimal three-dimensional perturbations in a fluttering and non-fluttering bioprosthetic aortic valve. *Journal of Fluid Mechanics*.

PREPRINTS

1. **Bornemann K-M**, Choi PS, Huber J, Reed AK, Sharir A, Maskatia SA, Marsden AL, Ma MR, Kaiser AD. Simulations predict improved valve performance without direct leaflet intervention after neonatal truncus arteriosus repair. *arXiv*:*2601.08932*, 2026. DOI

INVITED SEMINARS

1. "Fluid-structure interaction simulations of heart valves: From aortic valve prostheses for adults to congenital valve diseases in newborn children", Technical University Dresden, Dresden, Germany, 2026
2. "Heart valve mechanics: From transcatheter aortic valve thrombosis to congenital valve disease", Introduction to Bioengineering Research, Stanford University, Stanford, USA, 2025
3. "Experimental and numerical insights into laminar-turbulent transition mechanisms in bioprosthetic aortic valves", MEchanics GAthering – MEGA – Seminar, EPFL, Lausanne, Switzerland, 2024
4. "Computational Modelling of the Cardiovascular System: Fluid-Structure-Interaction Simulations of Heart Valves", Cardiovascular Technology, University of Bern, Switzerland, 2023
5. "Computational Modelling of the Cardiovascular System: Fluid-Structure-Interaction Simulations of Heart Valves", Cardiovascular Technology, University of Bern, Switzerland, 2022
6. "Mechanisms of laminar-turbulent transition past bioprosthetic aortic valves", Cardiovascular Technology, University of Bern, Switzerland, 2021

CONFERENCE ABSTRACTS

1. **Bornemann K-M**, Choi PS, Huber J, Sharir A, Maskatia SA, Ma MR, Marsden AL, Kaiser AD. Computational modeling of a quadricuspid truncal valve in neonatal hemodynamic conditions. *APS DFD,* 2025
2. **Bornemann K-M**, Choi PS, Huber J, Sharir A, Maskatia SA, Marsden AL, Kaiser AD, Ma MR: Computational modeling of a quadricuspid truncal valve in a neonate after truncal repair. *MCHRI Symposium*, 2025.
3. **Bornemann K-M**, Kaiser AD, Choi PS, Huber J, Sharir A, Maskatia SA, Marsden AL, Ma MR: Computational modeling of a quadricuspid truncal valve in a neonate before and after truncal repair. *Bay Area Symp.,* 2025
4. Choi PS, Tarun S, Sharir A, Huber J, Shibata M, **Bornemann K-M**, Kaiser AD, Marsden AL, Ma MR: Ex-vivo Assessment of Pulmonary Valve Leaflet Replacement Using Autologous Pulmonary Arterial Wall. *Korean Heart Valve Conference*, 2025.
5. **Bornemann K-M**, Jahren SE, Obrist D: Effect of bioprosthetic heart valve design on leaflet fluttering and laminar-turbulent transition. *EFDC2*, 2025
6. **Bornemann K-M**, Jahren SE, Obrist D: The relation between bioprosthetic valve design, leaflet fluttering and laminar-turbulent transition. *CMBBE 2025*, 2025
7. **Bornemann K-M**, Obrist D: Transition to turbulence past bioprosthetic aortic valves. *APS DFD,* 2024
8. **Bornemann K-M**, Obrist D: The influence of aortic wall geometry and leaflet fluttering on three-dimensional laminar-turbulent transition mechanisms past bioprosthetic aortic valves. *EFDC1*, 2024
9. **Bornemann K-M**, Jahren SE, Corso P, Demirel C, Stortecky S, Obrist D: Investigation of sinus washout and platelet activation in transcatheter valve thrombosis patients. *HVS*, 2024
10. **Bornemann K-M**, Obrist D: Three-dimensional laminar-turbulent transition mechanisms downstream of a bioprosthetic aortic valve. *ETC18,* 2023
11. **Bornemann K-M**, Jahren SE, Corso P, Demirel C, Stortecky S, Obrist D: Particle tracing in aortic root models investigating sinus washout in transcatheter valve thrombosis patients. *ESBiomech23*, 2023
12. **Bornemann K-M**, Jahren SE, Corso P, Demirel C, Stortecky S, Obrist D: Blood flow patterns in larger aortic roots promote thrombus formation: The missing link between aortic root morphology and transcatheter aortic heart valve thrombosis? *CFC2023*, 2023
13. **Bornemann K-M**, Jahren SE, Corso P, Demirel C, Stortecky S, Obrist D: Connection between larger aortic diameters and transcatheter aortic heart valve thrombosis: A computational study. *HVS,* 2023
14. **Bornemann K-M**, Corso P, Obrist D: Geometrical parameterization of the aortic wall to investigate the evolution of hydrodynamic instabilities initiating laminar-turbulent transition past bioprosthetic aortic valves. *EFMC14*, 2022