BIOGRAPHICAL SKETCH

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NAME: Jonathan F. Wenk, PhD

eRA COMMONS USER NAME: JONATHAN.WENK

POSITION TITLE: Associate Professor of Mechanical Engineering and Associate Professor of Surgery

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Purdue University, West Lafayette, IN	BS (Hons)	05/2003	Mechanical Engineering
University of California, Berkeley, CA	MS	12/2005	Mechanical Engineering
University of California, Berkeley, CA	PhD	12/2008	Mechanical Engineering
University of California, San Francisco, CA	Postdoc	07/2011	Bioengineering/Surgery

A. Personal Statement

My long-term research goals focus on the simulation of ventricular and valvular structures in order to evaluate the effects of disease and treatment strategies. My primary efforts have been to develop a computational tool that can be used to test how modifications to specific molecules alter ventricular function. Ultimately, this work might help to optimize patient-specific therapies for men and women with heart failure. My work uses a multiscale approach that integrates molecular-level mechanisms, which account for alterations due to genetic mutation and targeted drug therapy, with organ-level ventricular pump function. This is possible due to the coupling of a molecular/cellular computer code into my finite element framework. I have also worked on developing an approach that can be used to identify the mechanical properties of the mitral valve leaflets. This is accomplished by using a combination of experimental measurements and computational modeling. This validated model can then be used to test various treatment strategies for improving valve/ventricular function. My background in evaluating functional and structural changes in the heart, due to various disease states, has equipped me with all of the tools that are necessary to mentor trainees in biomedical research. In particular, I have developed novel computational techniques that can be used to evaluate the mechanics of the cardiovascular system. I have demonstrated a record of productive research in cardiac mechanics, and my experience has uniquely prepared me for collaboration in the University of Kentucky Center for Clinical and Translational Science (CCTS).

It should be noted that I have extensive experience mentoring both students and postdocs on projects related to cardiovascular mechanics. In the past 9 years I have advised 16 undergraduate students, 13 graduate students, and 3 postdocs. Of these undergraduate students, several have gone on to purse graduate or medical school, with one student currently enrolled in UK's MD/PhD program. My former PhD students have taken postdocs and faculty positions all over the world, and are continuing to contribute to biomedical research. As part of the CCTS, I will participate in the Training (TL1) Core. This will allow me to continue to mentor trainees at the interface of engineering and medicine, with the goal of developing new computational tools that will help translate fundamental research into clinical diagnostic tools. In the publications listed in this document, underlined names indicate a student or postdoc under my supervision.

1. Stephens, S. E., Liachenko, S., Ingels, N., **Wenk, J. F.**, and Jensen, M. O., 2017, "High Resolution Imaging of the Unloaded Mitral Valve in the Natural State with 7 Tesla MRI," *PLoS ONE*, **12(8)**, e0184042. PMCID: PMC5576658
2. Liu, Z-Q., Zhang, X., and **Wenk, J. F.**, 2019, "Quantification of regional right ventricular strain in healthy rats using 3d spiral cine dense MRI," *Journal of Biomechanics*, **94**, pp. 219-223. PMCID: PMC6736687

3. Zhang, X., Haynes, P., Campbell, K. S., and **Wenk, J. F.**, 2015, "Numerical Evaluation of Myofiber Orientation and Transmural Contractile Strength on Left Ventricular Function," *Journal of Biomechanical Engineering,* **137(4)**, 044502. PMID: 25367232
4. Nikou, A., Dorsey, S. M., McGarvey, J. R., Gorman III, J. H., Burdick, J. A., Pilla, J. J., Gorman, R. C., and **Wenk, J. F.**, 2015, "Computational Modeling of Healthy Myocardium in Diastole," *Annals of Biomedical Engineering,* **44(4)**, pp. 980-992. PMCID: PMC4731326

B. Positions and Honors

Positions and Employment

2008-2009	Research Consultant (on computational modeling), CardioPolymers, Inc., Laguna Hills, CA
2011-2017	Assistant Professor, Department of Mechanical Engineering, Department of Surgery (by joint appointment); University of Kentucky, Lexington, KY
2017-present	Associate Professor, Department of Mechanical Engineering, Department of Surgery (by joint appointment); University of Kentucky, Lexington, KY

Honors and Awards

2005	Outstanding Graduate Student Instructor Award, University of California, Berkeley
2012	ASME Bluegrass Chapter Outstanding Faculty Award, University of Kentucky
2014	STLE Frank P. Bussick Award
2017	Gill Professor in Engineering (5 year Endowed Professorship), University of Kentucky

Manuscript Reviewing

Acta Biomaterialia, Computer Methods in Biomechanics and Biomedical Engineering, Cardiovascular Engineering and Technology, Journal of Biomechanical Engineering, Medical & Biological Engineering & Computing, Journal of Biomechanics, Medical Engineering & Physics, Biomechanics and Modeling in Mechanobiology, Journal of the Royal Society Interface, Circulation, The American Journal of Cardiology, Computers in Biology and Medicine, Frontiers in Physiology, Magnetic Resonance Imaging, PLOS Computational Biology, Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences.

Grant Reviewing

2012-present	American Heart Association
2018-present	National Science Foundation

Professional Memberships

2007-present	United States Association for Computational Mechanics
2007-present	International Association for Computational Mechanics
2009-present	American Society of Mechanical Engineers
2009-present	Biomedical Engineering Society
2013-present	American Heart Association

C. Contributions to Science

Complete list of published work in NCBI My Bibliography
http://www.ncbi.nlm.nih.gov/myncbi/browse/collection/42789182/?sort=date&direction=descending

1. **Inverse calculations of myocardial mechanical properties.** Over the past 12 years, I have used a combination of cardiac MRI, finite element modeling, and numerical optimization to estimate the mechanical properties of both passive and active myocardium. This is accomplished by comparing the deformation (strain) calculated from the experimental MRI data with that predicted by the ventricular finite element models. These studies have predicted increased passive stiffness of infarcted tissue, as well as depressed contractility in the border zone myocardium near an infarct. Both of these results have been confirmed with ex vivo experiments.

a. Mann, C. K., Lee, L. C., Campbell, K. S., and **Wenk, J. F.**, 2020, "Force-dependent recruitment from myosin OFF-state increases end-systolic pressure–volume relationship in left ventricle," *Biomechanics and Modeling in Mechanobiology*, **19(6)**, pp. 2683-2692. PMCID: PMC7606253
b. Wang, H., Zhang, X., Dorsey, S. M., McGarvey, J. R., Campbell, K. S., Burdick, J. A., Gorman III, J. H., Pilla, J. J., Gorman, R. C., and **Wenk, J. F.**, 2016, "Computational Investigation of Transmural Differences in Left Ventricular Contractility," *Journal of Biomechanical Engineering,* **138(11)**, 114501. PMCID: PMC5125313
c. Zhang, X., Liu, Z., Campbell, K. S., and **Wenk, J. F.**, 2018, "Evaluation of a Novel Finite Element Model of Active Contraction in the Heart," *Frontiers in Physiology,* **9**, 425. PMCID: PMC5924776
d. Mojsejenko, D., McGarvey, J. R., Dorsey, S. M., Gorman III, J. H., Burdick, J. A., Pilla, J. J., Gorman, R. C., and **Wenk, J. F.**, 2015, "Estimating Passive Mechanical Properties in a Myocardial Infarction using MRI and Finite Element Simulations," *Biomechanics and Modeling in Mechanobiology,* **14(3)**, pp. 633-647. PMCID: PMC4398581

2. **Investigating the effects of myocardial infarction.** In order to assess the temporal changes in mechanical properties, I have used finite element modeling and in-vivo data (as described in the previous section) to predict changes in infarct stiffness over a 12-week period (post infarction) in porcine. This work showed the lateral wall infarcts become extremely stiff at 1-week post-infarct and then become progressively less stiff. I have also investigated how myocardial infarction leads to dysfunction in the contractile properties of border zone myocardium near an infarct. The in vivo properties were predicted using computer modeling to assess both sheep and human left ventricles after infarction. The decrease in contraction was confirmed with ex vivo experiments of border zone tissue from sheep with infarction.

a. McGarvey, J. R., Mojsejenko, D., Dorsey, S. M., Nikou, A., Burdick, J. A., Gorman III, J. H., Jackson, B. M., Pilla, J. J., Gorman, R. C., and **Wenk, J. F.**, 2015, "Temporal Changes in Infarct Material Properties: An *In Vivo* Assessment using MRI and Finite Element Simulations," *Annals of Thoracic Surgery,* **100(2)**, pp. 582-589. PMID: 26095107
b. Wang, H., Rodell, C. B., Zhang, X., Dusaj, N. N., Gorman III, J. H., Pilla, J. J., Jackson, B. M., Burdick, J.A., Gorman, R. C., and **Wenk, J. F.**, 2018, "Effects of Hydrogel Injection on Borderzone Contractility Post Myocardial Infarction," *Biomechanics and Modeling in Mechanobiology*, **17(5)**, pp. 1533-1542. PMID: 29855734
c. **Wenk, J. F.**, Zhang, Z., Cheng, G., Malhotra, D., Acevedo-Bolton, G., Burger, M., Suzuki, T., Saloner, D. A., Wallace, A. W., Guccione, J. G., and Ratcliffe, M. B., 2010, "First Finite Element Model of the Left Ventricle with Mitral Valve: Insights into Ischemic Mitral Regurgitation," *Annals of Thoracic Surgery*, **89(5)**, pp. 1546-1553. PMCID: PMC2887313
d. **Wenk, J. F.**, Sun, K., Zhang, Z., Soleimani, M., Ge, L., Saloner, D. A., Wallace, A. W., Ratcliffe, M. B., and Guccione, J. M., 2011, "Regional Left Ventricular Myocardial Contractility and Stress in a Finite Element Model of Posterobasal Myocardial Infarction," *Journal of Biomechanical Engineering*, **133(4)**, 044501. PMCID: PMC3097530

3. **Growth and remodeling of ventricular myocardium.** Over the last several years, I have worked with Dr. Lee (MSU) to develop finite element models that use growth and remodeling algorithms to alter the geometry of the ventricle due to changes in pressure loading. Patient-specific MRI data was used to assess growth and remodeling before and after surgical ventricular restoration surgery. It was found that the surgery does not prevent adverse remodeling, which is consistent with clinical observations. Another study used a growth and remodeling algorithm that was coupled to an electromechanical model to investigate the effects of infarct stiffness on ventricular function. It was found that stiffer infarcts reduce the amount of adverse remodeling in both the remote and border zone myocardium.

a. Klepach, D., Lee, L. C., **Wenk, J. F.**, Ratcliffe, M. B., Zohdi, T. I., Navia, J. L., Kassab, G. S., Kuhl, E., and Guccione, J. M., 2012, "Growth and remodeling of the left ventricle: A case study of myocardial infarction and surgical ventricular restoration," *Mechanics Research Communications*, **42**, pp. 134-141. PMCID: PMC3390946

b. Lee, L. C., **Wenk, J. F.**, Klepach, D., Zhang, Z., Zhong, L., Ge, L., Ratcliffe, M. B., Navia, J. L., Kassab, G. S., and Guccione, J. M., 2013, "Physics-based Analysis of Patient-specific Surgical Ventricular Restoration – Importance of an Ellipsoid Left Ventricular Geometry for Diastolic and Systolic Function," *Journal of Applied Physiology,* **115(1)**, pp. 136-144. PMCID: PMC3727014
c. Lee, L. C., Sundnes, J., Genet, M., **Wenk, J. F.**, and Wall, S. T., 2016, "An Integrated Electromechanical-Reversible Growth Heart Model for Simulating Cardiac Therapies," *Biomechanics and Modeling in Mechanobiology,* **15(4)**, pp.791-803. PMID: 26376641
d. Nikou, A., Dorsey, S. M., McGarvey, J. R., Gorman III, J. H., Burdick, J. A., Pilla, J. J., Gorman, R. C., and **Wenk, J. F.**, 2016, "Effects of Using the Unloaded Configuration in Predicting the In Vivo Diastolic Properties of the Heart," *Computer Methods in Biomechanics and Biomedical Engineering,* **19(16)**, pp.1714-1720. PMCID: PMC5278778

4. **Investigating the effects of medical devices and treatment.** I have investigated the effects of injecting biomaterials (such as alginate and hydrogel) into myocardium and infarcted tissue, as a means of improving long-term ventricular function. It was found that injections reduce stress in the myocardium, as well as alter the mechanical stiffness of the tissue. By tuning the properties of the injectate material, this could have a long-term benefit to pump function. In addition, studies were conducted to evaluate the effects of the CorCap cardiac support device. While the myocardial wall stress was found to decrease, pump function was also found to decrease (acutely) and the pre-tension in the device had a significant effect on pump function.
   a. Wang, H., Rodell, C. B., Lee, M. E., Dusaj, N. N., Gorman III, J. H., Burdick, J.A., Gorman, R. C., and **Wenk, J. F.**, 2017, "Computational Sensitivity Investigation of Hydrogel Injection Characteristics for Myocardial Support," *Journal of Biomechanics*, **64**, pp. 231-235. PMCID: PMC5694362
   b. Dorsey, S. M., McGarvey, J. R., Wang, H., Nikou, A., Arama, L., Koomalsingh, K. J., Kondo, N., Gorman III, J. H., , Pilla, J. J., Gorman, R. C., **Wenk, J. F.**, and Burdick, J. A., 2015, "MRI Evaluation of Injectable Hyaluronic Acid Hydrogel Therapy to Limit Ventricular Remodeling after Myocardial Infarction," *Biomaterials,* **69**, pp. 65-75. PMCID: PMC4556569
   c. **Wenk, J. F.**, Wall, S. T., Peterson, R. C., Helgerson, S. L., Sabbah, H. N., Burger, M., Stander, N., Ratcliffe, M. B., and Guccione, J. M., 2009, "A Method for Automatically Optimizing Medical Devices for Treating Heart Failure: Designing Polymeric Injection Patterns," *Journal of Biomechanical Engineering*, **131(12)**, 121011. PMID: 20524734
   d. Kichula, E. T., Wang, H., Dorsey, S. M., Szczesny, S. E., Elliott, D. M., Burdick, J. A., and **Wenk, J. F.**, 2014, "Experimental and Computational Investigation of Altered Mechanical Properties in Myocardium after Hydrogel Injection," *Annals of Biomedical Engineering,* **42(7)**, pp. 1546-1556. PMCID: PMC4032381

5. **Mitral valve modeling and mechanics.** In terms of valvular structures, I have used finite element modeling to look at the effects of myocardial infarction on mitral regurgitation. One of the most significant studies investigated how infarct stiffness affects the coaptation of the mitral leaflets. This study was conducted with a sheep model of myocardial infarction and showed that stiffening the infarct can reduce the amount of regurgitation through the valve. In follow up investigations, the effects of annuloplasty rings on preventing mitral regurgitation were investigated. It was found that the stiffness and shape of the rings have a significant influence on regurgitation and stress in the leaflets.
   a. Stephens, S. E., Bean, M., Surber, H., Ingels, N. B., Jensen, H. K., Liachenko, S., **Wenk, J. F.**, and Jensen, M. O., 2021, "MicroCT Imaging of Heart Valve Tissue in Fluid," *Experimental Mechanics*, **61**, pp. 253-261.
   b. **Wenk, J. F.**, Zhang, Z., Cheng, G., Malhotra, D., Acevedo-Bolton, G., Burger, M., Suzuki, T., Saloner, D. A., Wallace, A. W., Guccione, J. G., and Ratcliffe, M. B., 2010, "First Finite Element Model of the Left Ventricle with Mitral Valve: Insights into Ischemic Mitral Regurgitation," *Annals of Thoracic Surgery*, **89(5)**, pp. 1546-1553. PMCID: PMC2887313
   c. **Wenk, J. F.**, Ratcliffe, M. B., and Guccione, J. M., 2012, "Finite Element Modeling of Mitral Leaflet Tissue using a Layered Shell Approximation," *Medical & Biological Engineering & Computing*, **50(10)**, pp. 1071-1079. PMCID: PMC3477701
   d. Wong, V. M., **Wenk, J. F.**, Zhang, Z., Cheng, G., Acevedo-Bolton, G., Burger, M., Saloner, D. A., Wallace, A. W., Guccione, J. M., Ratcliffe, M. B., and Ge, L., 2012, "The effect of mitral annuloplasty shape in ischemic mitral regurgitation: A finite element simulation," *Annals of Thoracic Surgery*, **93(3)**, pp. 776-782. PMCID: PMC3432639

D. Additional Information: Research Support

Ongoing Research Support

NIH U01 HL133359 Wenk, Campbell (MPIs) 08/03/2017-07/31/2022
National Heart, Lung and Blood Institute
Title: Multiscale Modeling of Inherited Cardiomyopathies and Therapeutic Interventions
Major goal: To develop a novel finite element framework that incorporates the effects of growth and remodeling due to sarcomere-level genetic mutations and drug therapies.
Role: PI

NIH R15 HL145585 Jensen (PI) 09/01/2019-08/31/2022
National Heart, Lung and Blood Institute
Title: Force Validated Heart Valve Surgical Planning Tool
Major goal: To develop a finite element model of the healthy mitral apparatus, which is validated with experimental force measurements, for determining the material properties of the valve.
Role: Co-I

OIA-1826715 DeBolt (PI) 08/15/2018-07/31/2022
National Science Foundation
Title: A Multiscale, Multiphysics Modeling Framework For Genome-To Phenome Mapping Via Intermediate Phenotypes
Major goal: To develop a more advanced mathematical/statistical framework for capturing multiscale nonlinear interactions and functional relationships to provide a complete picture of genome-phenome relationships.
Role: Senior Personnel

Completed Research Support

CMMI-1538754 Wenk (PI) 09/01/2015-08/31/2019
National Science Foundation
Title: Multiscale modeling of left and right ventricular function
Major goal: To develop a multiscale finite element model that incorporates both the left and right ventricle.
Role: PI

NIH R01 HL063954 Gorman (PI) 03/10/2015-01/31/2019
National Heart, Lung and Blood Institute
Title: Surgery to Prevent Postinfarction Ventricular Remodeling
Major goal: Utilize experimental and computational tools to develop hydrogel injection therapies for treating myocardial infarction.
Role: Co-I

AHA 15GRNT25460003 Campbell (PI) 07/01/2015-06/30/2018
American Heart Association Great Rivers Affiliate
Title: Transmural variation in cellular level contraction
Major goal: To investigate transmural differences in human myocardium with respect to heart disease and potential effects of mechanical unloading.
Role: Co-I

AHA 14BGIA18850020 Wenk (PI) 01/01/2014-12/31/2016
American Heart Association Great Rivers Affiliate
Title: Computer-assisted optimization of therapies for heart failure
Major goal: To develop a fully time-dependent finite element model of the left ventricle that includes transmural variation in contractile properties.
Role: PI

Pilot project on NIH P30 GM110787 Campbell (PI) 08/13/2014-04/30/2016
University of Kentucky Center for Molecular Medicine
Title: Molecular mechanisms of cardiac dysfunction
Major goal: To investigate transmural differences in molecular/cellular level function in rats with aging-associated heart failure.
Role: Co-I