Eric D. Carruth, PhD

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Education

PhD : Bioengineering University of California San Diego 2012 – 2018
Mentors: Jeff Omens, Andrew McCulloch

BS : Biomedical Engineering University of Utah 2008 – 2012

Research Focus

As we continue to learn about the relationships between rare variants in cardiomyopathy-associated genes and phenotype development, our understanding of the factors that contribute to incomplete penetrance and variable expressivity remains limited. My research focus will be to study **the interaction of rare variants with other genetic, behavioral and clinical factors** (e.g. exercise, smoking status, hypertension, or chemotherapy) on cardiac disease progression and development. The expansion of population-based genome sequencing initiatives enables the study of these interactions in a general population, as opposed to traditional, symptom-based approaches. This work will aid healthcare providers and patients in the management of incidental genomic findings by providing estimates of disease penetrance, optimal follow-up patterns, and lifestyle modifications to mitigate adverse outcomes.

Work Experience

Geisinger : *Assistant Professor* Nov 2022 – Present

- Developing novel research studies to understand the relationships between rare genetic variants and behavioral or clinical stressors on cardiac structure and function using whole exome sequencing data, electronic health records, and advanced MRI from a large healthcare-seeking population
- Examining sub-clinical manifestations of disease development in patients with cardiomyopathy-associated genetic variants but no observable clinical phenotype using motion-sensitive MRI

Geisinger : *Staff Scientist* Aug 2018 – Nov 2022

- Improved population-based estimates of disease penetrance in individuals with desmosome gene variants associated with arrhythmogenic cardiomyopathy in a clinical population ($\sim$6%)
- Examined the predicted risk of ventricular arrhythmias in a genome-first ACM cohort, where predicted risk is low but varies based on genotype and affected ventricle
- Optimized an MRI acquisition method for high-resolution 3D myocardial strain imaging (DENSE) in the right ventricle during a breath hold

University of California, San Diego : *Graduate Student Researcher* Aug 2012 – Aug 2018

- Provided key medical imaging expertise to team of data scientists developing deep learning methods for automated segmentation of cardiac MRI
- Characterized 8 novel spatially heterogeneous structural patterns in healthy and diseased cardiac tissue through detailed spatial analysis of high-resolution Diffusion Tensor MRI data
- Optimized *ex vivo* Diffusion Tensor MRI acquisition of excised rat heart, improving resolution (60%) and signal-to-noise ratio (50%)
- Managed global, multi-disciplinary teams of collaborators resulting in high quality data acquisition and model generation from MRI, and multiple journal articles
- Instructed dozens of masters and undergraduate students on generating models of cardiac structure and biomechanics from MRI and computed tomography (CT) data in Seg3D, Osirix, and Blender

University of Utah : *Undergraduate Research Assistant* Dec 2008 – Aug 2012

– Performed histology, immunofluorescence, confocal microscopy, deconvolution in MatLab, segmentation of 3D images, and 3D myocyte model generation for electrophysiological modeling studies
– Segmented bone and cartilage features from CT scans of the hip joint in Amira, created and ran finite element models from image data, and analyzed results in MatLab

AWARDS

Grants

NHLBI T32 Grant Recipient: Interfaces Training Program 2013 – 2018

Scholarships

Department of Bioengineering Tuition Waiver Scholarship 2011
Match Scholarship 2010
Christopher and Kathryn Porter Scholarship 2009

Other awards

Undergraduate Research Scholar Award 2012
Dean's Honor Lists 2009 – 2012

PUBLICATIONS

1. Carruth, E. D. *et al.* Loss-of-Function FLNC Variants Are Associated With Arrhythmogenic Cardiomyopathy Phenotypes When Identified Through Exome Sequencing of a General Clinical Population. *Circulation: Genomic and Precision Medicine.* ISSN: 2574-8300. https://www.ahajournals.org/doi/abs/10.1161/CIRCGEN.121.003645 (June 2022).

2. Carruth, E. D. *et al.* Clinical Findings and Diagnostic Yield of Arrhythmogenic Cardiomyopathy through Genomic Screening of Pathogenic or Likely Pathogenic Desmosome Gene Variants. *Circulation: Genomic and Precision Medicine* **14,** 201–212. ISSN: 25748300. http://www.ncbi.nlm.nih.gov/pubmed/33684294 (2 Apr. 2021).

3. Carruth, E. D. *et al.* 3D-Encoded DENSE MRI with Zonal Excitation for Quantifying Biventricular Myocardial Strain During a Breath-Hold. *Cardiovascular Engineering and Technology,* 1–9. ISSN: 18694098. https://link.springer.com/article/10.1007/s13239-021-00561-8 (July 2021).

4. Carruth, E. D. *et al.* Regional variations in ex-vivo diffusion tensor anisotropy are associated with cardiomyocyte remodeling in rats after left ventricular pressure overload. *Journal of Cardiovascular Magnetic Resonance* **22,** 21. ISSN: 1532429X. https://doi.org/10.1186/s12968-020-00615-1 (1 2020).

5. Teh, I. *et al.* Improved compressed sensing and super-resolution of cardiac diffusion MRI with structure-guided total variation. *Magnetic Resonance in Medicine* **84,** 1868–1880. ISSN: 15222594. https://onlinelibrary.wiley.com/doi/abs/10.1002/mrm.28245 (4 Mar. 2020).

6. Carruth, E. D. *et al.* Prevalence and Electronic Health Record-Based Phenotype of Loss-of-Function Genetic Variants in Arrhythmogenic Right Ventricular Cardiomyopathy-Associated Genes. *Circulation: Genomic and Precision Medicine* **12,** 487–494. ISSN: 2574-8300. https://www.ahajournals.org/doi/10.1161/CIRCGEN.119.002579 (11 Nov. 2019).

7. Lewalle, A. *et al.* Decreasing Compensatory Ability of Concentric Ventricular Hypertrophy in Aortic-Banded Rat Hearts. *Frontiers in Physiology* **9.** ISSN: 1664-042X. http://journal.frontiersin.org/article/10.3389/fphys.2018.00037/full (Feb. 2018).

8. Carruth, E. D. *et al.* Transmural gradients of myocardial structure and mechanics: Implications for fiber stress and strain in pressure overload. *Progress in Biophysics and Molecular Biology* **122,** 215–226. ISSN: 00796107. https://linkinghub.elsevier.com/retrieve/pii/S0079610716301511 (3 Dec. 2016).

9. McClymont, D. *et al.* Evaluation of non-Gaussian diffusion in cardiac MRI. *Magnetic resonance in medicine.* https://onlinelibrary.wiley.com/doi/10.1002/mrm.26466 (Sept. 2016).

10. Lichter, J. G. *et al.* Remodeling of the sarcomeric cytoskeleton in cardiac ventricular myocytes during heart failure and after cardiac resynchronization therapy. *Journal of Molecular and Cellular Cardiology* **72,** 186–195. ISSN: 00222828. https://linkinghub.elsevier.com/retrieve/pii/S0022282814000893 (July 2014).

11. Henak, C. *et al.* Finite element predictions of cartilage contact mechanics in hips with retroverted acetabula. *Osteoarthritis and Cartilage* **21,** 1522–1529. ISSN: 10634584. https://linkinghub.elsevier.com/retrieve/pii/S1063458413008443 (10 Oct. 2013).

12. Schwab, B. C. *et al.* Quantitative Analysis of Cardiac Tissue Including Fibroblasts Using Three-Dimensional Confocal Microscopy and Image Reconstruction: Towards a Basis for Electrophysiological Modeling. *IEEE Transactions on Medical Imaging* **32,** 862–872. ISSN: 0278-0062. http://ieeexplore.ieee.org/document/6414638/ (5 May 2013).

13. Lackey, D. P. *et al.* Three-Dimensional Modeling and Quantitative Analysis of Gap Junction Distributions in Cardiac Tissue. *Annals of Biomedical Engineering* **39,** 2683–2694. ISSN: 0090-6964. http://link.springer.com/10.1007/s10439-011-0369-3 (11 Nov. 2011).