

Patrick M Boyle, PhD, PEng, FHRS

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CURRENT RESEARCH ACTIVITY

My research aims to use cutting edge computer simulations of the human heart to cultivate new knowledge about the underlying mechanisms of lethal cardiac arrhythmias and to develop novel strategies to treat these complex conditions. At present, I am focused on two projects: (1) using patient-specific “virtual heart” models reconstructed from clinical imaging to derive *custom-tailored atrial fibrillation ablation treatment plans*, and (2) assessing the feasibility of novel anti-arrhythmic strategies based on *cardiac optogenetics*. I also have an over-arching interest in *driving technological development* to enable and accelerate projects that seek to diagnose and treat cardiovascular disease using predictive computational modeling and data-driven approaches. Here, my goal is to *shift the window of feasibility* from small pilot studies (tens of patients) to large-scale, multi-center, randomized clinical trials (hundreds or thousands of patients).

Expertise: Biomedical Engineering • Personalized Medicine • Optogenetics • Arrhythmia
Computational Cardiology • Defibrillation • Parallel Computing • Finite Element Simulation

Metrics (via [Google Scholar](#)): 856 citations • *h*-index: 18 • *i10*-index: 28

ACADEMIC APPOINTMENTS

- 2015–now Assistant Research Professor, Department of Biomedical Engineering, Johns Hopkins University
- 2015–now Assistant Research Professor, Institute for Computational Medicine, Johns Hopkins University
- 2014–15 Assistant Research Scientist, Institute for Computational Medicine, Johns Hopkins University
- 2011–14 NSERC Postdoctoral Fellow, Institute for Computational Medicine, Johns Hopkins University
Supervisor: Natalia A Trayanova, PhD, Professor of Biomedical Engineering

EDUCATION

- 2011 PhD in Biomedical Engineering, University of Calgary
Thesis title: *Roles of the Purkinje System During Electric Shocks and Arrhythmia*
Supervisor: Edward J Vigmond, PhD, Professor of Electrical Engineering
- 2005 BSc with Distinction in Computer Engineering, internship program, University of Calgary

PROFESSIONAL EXPERIENCE

- 2003–04 Broadcast Multimedia Department, Sanyo Electric Co. Ltd., Osaka, Japan: *Developed a multicast architecture for streaming high-definition video over unreliable networks during an 11-month internship.*
- 2002–05 Westhoff Engineering Resources, Calgary, AB: *Designed software for analyzing hydrological data and cataloguing scientific literature during two summer terms and part-time hours during university.*

GRANTS, HONOURS, AND AWARDS

GRANT SUPPORT

- 2016–19 **American Heart Association Scientist Development Grant (PI)** *“Patient-specific modeling to unveil mechanistic insights on perpetuation and ablation of persistent atrial fibrillation.”* (3 years, \$231,000)
- 2011–13 **Natural Sciences and Engineering Research Council Post-Doctoral Fellowship (PI)** *“Identifying mechanisms of transition between early and long-duration ventricular fibrillation.”* (2 years, CAD \$80,000)

RESEARCH AWARDS

- 2011 AStech Foundation Leaders of Tomorrow Honouree
- 2010 APEGA Education Foundation Graduate Scholarship
- 2010 Queen Elizabeth II Scholarship
- 2008–10 Alberta Ingenuity Student Scholarship
- 2008–10 NSERC Post-Graduate Scholarship D
- 2005–07 iCORE Graduate Scholarship
- 2005–07 NSERC Post-Graduate Scholarship M

OTHER ACADEMIC AWARDS AND HONOURS

- 2017 Official Selection for “EP Concepts Ignited: Innovative Techniques and Technologies” session at *Heart Rhythm Society (HRS) Annual Scientific Sessions*
- 2012 Outstanding Scientific Poster Presentation, *Cardiac Physiome Workshop*
- 2012 Rosanna Degani Young Investigator Award Finalist, *Computing in Cardiology Conference*
- 2011 Lifetime Achievement Award, *University of Calgary Graduate Students’ Association*
- 2010 Graduate Citizenship Award, *Government of Alberta*
- 2009 Best Overall Poster, *Alberta Biomedical Engineering Conference*
- 2009 Best Oral Presentation, *Alberta ECE Graduate Research Symposium*
- 2007–08 Teaching Assistant Excellence Award, *University of Calgary*
- 2007 Teaching Excellence Award (shortlist), *University of Calgary*
- 2007 Best Oral Presentation, *Alberta BME Conference*
- 2004 Engineering Internship Merit Award (nominee), *University of Calgary*
- 2001 Louise McKinney Scholarship, *Government of Alberta*
- 2000 Alexander Rutherford Scholarship *Government of Alberta*
- 2000 Canadian National Advanced Placement Scholar Award, *College Board*

PUBLICATIONS, PATENTS, AND PRESENTATIONS

*: equal authorship contributions

MANUSCRIPTS CURRENTLY UNDER PEER REVIEW

(44) A Prakosa*, HJ Arevalo*, D Deng*, **PM Boyle**, PP Nikolov, H Ashikaga, JJE Blauer, E Ghafoori, CJ Park, RC Blake, FT Han, RS MacLeod, HR Halperin, DJ Callans, R Ranjan, J Chrispin, S Nazarian, NA Trayanova, “Personalized Virtual-heart Platform for Infarct-related Ventricular Tachycardia Ablation Guidance,” revised manuscript under review by *Nat Biomed Eng*.

(43) **PM Boyle**, JB Hakim, S Zahid, WH Franceschi, MJ Murphy, EJ Vigmond, R Dubois, M Haïssaguerre, M Hocini, P Jaïs, NA Trayanova*, H Cochet*, “Comparing Reentrant Drivers Predicted by Image-based Computational Modeling and Mapped by Electrocardiographic Imaging in Persistent Atrial Fibrillation,” revised manuscript under review by *Front Physiol*.

(42) J Yu, **PM Boyle**, A Klimas, JC Williams, NA Trayanova, E Entcheva, “OptoGap: An Optogenetics-Enabled Assay for Quantification of Cell-Cell Coupling in Multicellular Cardiac Tissue,” deposited to bioRxiv pre-print server (doi: [10.1101/171397](https://doi.org/10.1101/171397)), revised manuscript requested by *Nat Commun*.

(41) S Barichello, JD Roberts, PH Backx, **PM Boyle**, ZWM Laksman, “Personalizing Therapy for Atrial Fibrillation: the Role of Stem Cell and in Silico Disease Models,” revised manuscript requested by *Cardiovasc Res*.

ARTICLES ACCEPTED OR IN PRESS

(40) **PM Boyle**, TV Karathanos, NA Trayanova, “Cardiac Optogenetics: 2018,” *State-of-the-Art Review, JACC Clin Electrophysiol* (doi: [10.1016/j.jacep.2017.12.006](https://doi.org/10.1016/j.jacep.2017.12.006)).

ARTICLES PUBLISHED

2018 (39) **PM Boyle**, MJ Murphy, TV Karathanos, S Zahid, RC Blake, NA Trayanova “Termination of Re-entrant Atrial Tachycardia via Optogenetic Stimulation with Optimized Spatial Targeting: Insights from Computational Models,” *J Physiol*, 596(2):181–96.

(38) H Cochet, R Dubois, S Yamashita, N Al Jefairi, B Berte, J–M Sellal, D Hooks, A Frontera, S Amraoui, A Zemmoura, A Denis, N Derval, F Sacher, O Corneloup, V Latrabe, S Clément-Guinaudeau, J Relan, S Zahid, **PM Boyle**, NA Trayanova, O Bernus, M Montaudon, F Laurent, M Hocini, M Haïssaguerre, P Jaïs, “Relationship between Fibrosis detected on Late Gadolinium-enhanced MRI and Reentrant Activity assessed with ECGI in Human Persistent Atrial Fibrillation,” *JACC Clin Electrophysiol*, 4(1):17–29, *accompanied by editorial*.

(37) NA Trayanova, **PM Boyle**, P Nikolov, “Personalized Imaging and Modeling Strategies for Arrhythmia Prevention and Therapy,” *Curr Opin Biomed Eng*, 5(3):21–28.

- 2017 (36) D Deng*, MJ Murphy*, S Zahid, WH Franceschi, JB Hakim, NA Trayanova, **PM Boyle**, “Sensitivity of Reentrant Driver Localization to Electrophysiological Parameter Variability in Image-Based Computational Models of Persistent Atrial Fibrillation Sustained by a Fibrotic Substrate,” *Chaos*, 27:093932.
- (35) **PM Boyle**, S Zahid, NA Trayanova, “Using Personalized Computer Models to Custom-Tailor Ablation Procedures for Atrial Fibrillation Patients,” *Exp Rev Cardiovasc Ther*, 15(5):339–341.
- (34) M Deo, SH Weinberg, **PM Boyle**, “Calcium Dynamics and Cardiac Arrhythmia,” *Clin Med Insights Cardiol*, 11:1–4.
- 2016 (33) T Brüggmann*, **PM Boyle***, C Vogt, TV Karathanos, HJ Arevalo, B Fleischmann, NA Trayanova, P Sasse, “Optogenetic defibrillation of ventricular arrhythmia in mouse hearts and human simulations,” *J Clin Invest*, 126(10):3894–904.
- (32) S Zahid*, H Cochet*, **PM Boyle***, EL Schwarz, KN Whyte, EJ Vigmond, R Dubois, M Hocini, M Haïssaguerre, P Jaïs, NA Trayanova, “Patient-Derived Models Link Reentrant Driver Localization in Atrial Fibrillation to Fibrosis Spatial Pattern,” *Cardiovasc Res*, 110(3):443–54, *accompanied by editorial*.
- (31) S Zahid, KN Whyte, EL Schwarz, RC Blake, **PM Boyle**, J Chrispin, A Prakosa, EG Ipek, F Pashakhanloo, HA Halperin, H Calkins, RD Berger, S Nazarian, NA Trayanova, “Feasibility of Using Patient-Specific Models and the Minimum Cut Algorithm to Predict Optimal Ablation Targets for Left Atrial Flutter,” *Heart Rhythm*, 13(8):1687–98.
- (30) JR Priest, C Gawad, KM Kahlig, JK Yu, T O’Hara, **PM Boyle**, S Rajamani, M Clark, S Garcia, S Ceresnak, J Harris, S Boyle, F Dewey, L Malloy-Walton, K Dunn, M Grove, M Perez, N Neff, R Chen, K Maeda, A Dubin, L Belardinelli, J West, C Antolik, D Macaya, T Quertermous, NA Trayanova, S Quake, E Ashley, “Early Somatic Mosaicism is a Rare Cause of Long-QT Syndrome,” *Proc Natl Acad Sci*, 113(41):11555–60.
- (29) TV Karathanos, JD Bayer, D Wang, **PM Boyle***, NA Trayanova*, “Opsin Spectral Sensitivity Determines the Effectiveness of Optogenetic Termination of Ventricular Fibrillation in the Human Heart: A Simulation Study,” *J Physiol*, 594(23):6879–91.
- (28) **PM Boyle**, S Zahid, NA Trayanova, “Towards Personalized Computational Modelling of the Fibrotic Substrate for Atrial Arrhythmia,” *Europace*, 18:iv136–45.
- (27) C Roney, JD Bayer, S Zahid, M Meo, **PM Boyle**, NA Trayanova, R Dubois, H Cochet, EJ Vigmond, “Modelling Methodology of Atrial Fibrosis Affects Rotor Dynamics and Electrograms,” *Europace*, 18:iv146–55.
- (26) TV Karathanos, **PM Boyle**, NA Trayanova, “Light-Based Approaches to Cardiac Arrhythmia Research: From Basic Science to Translational Applications,” *Clin Med Insights Cardiol*, 10(S1):47.
- (25) HJ Arevalo, **PM Boyle**, NA Trayanova, “Computational Rabbit Models to Investigate the Initiation, Perpetuation, and Termination of Ventricular Arrhythmia,” *Prog Biophys Mol Biol*, 121(2):185–94.

- 2015 (24) CM Ambrosi*, **PM Boyle***, K Chen, NA Trayanova, E Entcheva, "Optogenetics-Enabled Assessment of Viral Gene and Cell Therapy for Restoration of Cardiac Excitability," *Sci Rep*, 5:17350.
- (23) **PM Boyle**, TV Karathanos, E Entcheva, NA Trayanova, "Computational Modeling of Cardiac Optogenetics: Methodology Overview and Review of Findings from Simulations," *Comp Biol Med*, 65:200–8.
- (22) FO Campos, Y Shiferaw, AJ Prassl, **PM Boyle**, EJ Vigmond, G Plank, "Stochastic Spontaneous Calcium Release Events Trigger Premature Ventricular Complexes by Overcoming Electrotonic Load," *Cardiovasc Res*, 107(1):175–83.
- (21) **PM Boyle**, TV Karathanos, NA Trayanova, "*Beauty is a Light in the Heart: The Transformative Potential of Optogenetics for Clinical Applications in Cardiovascular Medicine*," *Trends Cardiovasc Med*, 25(2):73–81.
- 2014 (20) TV Karathanos*, **PM Boyle***, NA Trayanova, "Optogenetics-Enabled Dynamic Modulation of Action Potential Duration in Atrial Tissue: Feasibility of a Novel Therapeutic Approach," *Europace*, 16(Suppl 4):iv69–76.
- (19) **PM Boyle***, CJ Park*, HJ Arevalo, EJ Vigmond, NA Trayanova, " I_{Na} Reduction Unmasks a Structure-Dependent Substrate for Arrhythmogenesis in the Normal Ventricles," *PLoS One*, 9(1):e86947.
- (18) **PM Boyle**, E Entcheva, NA Trayanova, "See the Light: Can Optogenetics Restore Healthy Heartbeats? And, if it Can, is it Really Worth the Effort?" *Exp Rev Cardiovasc Ther*, 12(1):17–20.
- (17) NA Trayanova, **PM Boyle**, HJ Arevalo, S Zahid, "Exploring Susceptibility to Atrial and Ventricular Arrhythmias Resulting from Remodeling of the Passive Electrical Properties in the Heart," *Front Physiol*, 5:435.
- (16) NA Trayanova, **PM Boyle**, "Advances in Modeling Ventricular Arrhythmias: from Mechanisms to the Clinic," *WIREs: Sys Biol Med*, 6(2):209–24.
- (15) N Zamiri, A Ramadeen, S Massé, M Kusha, X Hu, MA Azam, J Liu, PFH Lai, EJ Vigmond, **PM Boyle**, E Behradfar, A Al-Hesayen, MB Waxman, P Backx, P Dorian, K Nanthakumar, "Dantrolene Improves Survival Following Ventricular Fibrillation by Mitigating Impaired Calcium Handling in Animal Models," *Circulation*, 129(8):875–85.
- 2013 (14) **PM Boyle**, JC Williams, CM Ambrosi, E Entcheva, NA Trayanova, "A Comprehensive Multiscale Framework for Simulating Optogenetics in the Heart," *Nat Comms*, 4:2370.
- (13) **PM Boyle**, S Massé, K Nanthakumar, EJ Vigmond, "Transmural $I_{K(ATP)}$ Heterogeneity as a Determinant of Activation Rate Gradient During Early Ventricular Fibrillation," *Heart Rhythm*, 10(11):1710–7, *accompanied by editorial*.

- (12) **PM Boyle**, GD Veenhuizen, EJ Vigmond, “Fusion During Entrainment Of Orthodromic Reciprocating Tachycardia Is Enhanced For Basal Pacing Sites But Diminished When Pacing Near Purkinje System Endpoints,” *Heart Rhythm*, 10(3):444–51, *accompanied by editorial*.
- 2012 (11) **PM Boyle**, A Madhavan, MP Reid, EJ Vigmond, “Propagating Unstable Wavelets in Cardiac Tissue,” *Phys Rev E*, 85(1):011909.
- (10) NA Trayanova, T O’Hara, JD Bayer, **PM Boyle**, KS McDowell, J Constantino, HJ Arevalo, Y Hu, F Vadakkumpadan, “Computational Cardiology: How Computer Simulations Could be Used to Develop New Therapies and Advance Existing Ones,” *Europace*, 14(Suppl 5):v82–9.
- (9) **PM Boyle**, K Nanthakumar, EJ Vigmond, “Model-based Investigation of Transmural Gradients in Activation Rate During Ventricular Fibrillation,” *Intl J Bioelectromag*, 14(1):6–10.
- 2010 (8) **PM Boyle**, M Deo, G Plank, EJ Vigmond, “Purkinje-Mediated Effects in the Response of Quiescent Ventricles to Defibrillation Shocks,” *Ann Biomed Eng*, 38(2):456–68.
- (7) **PM Boyle**, EJ Vigmond, “An Intuitive Safety Factor for Cardiac Propagation,” *Biophys J*, 98(12):L57–9.
- (6) M Deo, **PM Boyle**, AM Kim, EJ Vigmond, “Arrhythmogenesis by Single Ectopic Beats Originating in the Purkinje System,” *Am J Physiol Heart Circ Physiol*, 299(4):H1002–11.
- (5) MJ Bishop, **PM Boyle**, G Plank, D Welsh, EJ Vigmond, “Modelling the Role of the Coronary Vasculature During External Field Stimulation,” *IEEE Trans Biomed Eng*, 57(10):2335–45.
- (4) HA Ghaly, **PM Boyle**, EJ Vigmond, Y Shimoni, A Nygren, “Simulations of Reduced Conduction Reserve in the Diabetic Rat Heart: Response to Uncoupling and Reduced Excitability,” *Ann Biomed Eng*, 38(4):1415–25.
- (3) D Romero, R Sebastian, BH Bijnens, V Zimmerman, **PM Boyle**, EJ Vigmond, AF Frangi, “Effects of the Purkinje System and Cardiac Geometry on Biventricular Pacing: A Model Study,” *Ann Biomed Eng*, 38(4):1388–98.
- 2009 (2) M Deo, **PM Boyle**, G Plank, EJ Vigmond, “Arrhythmogenic Mechanisms of the Purkinje System During Electric Shocks: A Modelling Study,” *Heart Rhythm*, 6(12):1782–9.
- (1) F Vadakkumpadan, LJ Rantner, B Tice, **PM Boyle**, AJ Prassl, EJ Vigmond, G Plank, NA Trayanova, “Image-Based Models of Cardiac Structure with Applications in Arrhythmia and Defibrillation Studies,” *J Electrocardiol*, 2(2):157.e1–10.

INVITED LECTURES

- 2018 (33) “Optogenetics as a transformative approach to anti-arrhythmia treatment,” Heart Rhythm Society Annual Scientific Sessions (Boston, MA).

- 2017 (32) "Characterizing Uncertainty in Computational Models of the Fibrotic Atria: Implications for Clinical Applications," Workshop on Mathematical Methods in Cardiac Electrophysiology (Ottawa, ON).
- (31) "New Frontiers in Cardiac Arrhythmia Research: The Emergent Power of Computational Modelling," IEEE Ottawa Section Seminar Series, Carleton University (Ottawa, ON).
- (30) "Modeling Electrophysiology at the Cell and Tissue Scales," CARPentry Summerschool on Computational Modeling of Cardiac Electromechanics, Medical University of Graz (Graz, Austria).
- (29) "Computational Cardiology: Engineering Radical New Approaches for the Treatment of Heart Rhythm Disorders," Imaging and BME Clinical Academic Group, King's College London (London, UK).
- (28) "Computational Cardiology: Engineering Radical New Approaches for the Treatment of Heart Rhythm Disorders," BME Department Seminar Series, McMaster University (Hamilton, ON).
- (27) "Computational Cardiology: Engineering Radical New Approaches for the Treatment of Heart Rhythm Disorders," BME Department Seminar Series, Ryerson University (Toronto, ON).
- (26) "Computational Cardiology: Engineering Radical New Approaches for the Treatment of Heart Rhythm Disorders," Laszlo Lecture Series, University of British Columbia (Vancouver, BC).
- (25) "Patient-Specific Simulations of Atrial Arrhythmia Enable Precision Catheter Ablation," Gordon Research Conference on Cardiac Arrhythmia Mechanisms (Ventura, CA).
- 2016 (24) "Personalized Computational Modelling of Patient Hearts: Brave New Waves in Cardiac Arrhythmia Treatment," Universität Bonn (Bonn, Germany).
- (23) "Modeling in Understanding Arrhythmogenesis," Stanford Biodesign New Arrhythmia Technologies Retreat (Stanford, CA).
- (22) "Computational Modeling of the Heart: Life on the Cutting Edge of Cardiac Arrhythmia Research," Libin Cardiovascular Institute (Calgary, AB).
- 2015 (21) "Local Complexity of the Fibrosis Spatial Pattern Determines the Locations of Stable Reentrant Sources in Persistent Atrial Fibrillation: Analysis from Patient-Specific Models," Heart Rhythm Annual Scientific Sessions (Boston, MA).
- (20) "Prevalence of Regions with Highly Intermingled Fibrotic and Non-Fibrotic Tissue is a Better Predictor of Arrhythmia Inducibility Than Total Fibrosis Burden: Analysis of Patient-Specific Models of Persistent Atrial Fibrillation," Heart Rhythm Annual Scientific Sessions (Boston, MA).
- (19) "Computational Modeling of the Heart: Life on the Cutting Edge of Cardiac Arrhythmia Research," BME Department Seminar Series, McGill University (Montreal, QC).

- (18) "Patient-specific modeling to unveil mechanistic insights on perpetuation and ablation of persistent atrial fibrillation," Libin Cardiovascular Institute (Calgary, AB).
- (17) "*Beauty is a Light in the Heart: The Transformative Potential of Optogenetics for Clinical Applications in Cardiovascular Medicine*," Medical University of Graz (Graz, Austria).
- 2014 (16) "Spatial Distribution of Light-Sensitive Cells Determines Effectiveness of Optogenetics-Based Termination of Atrial Arrhythmias," BMES Annual Meeting (San Antonio, TX).
- 2013 (15) "Modeling of Defibrillation," American Heart Association Annual Scientific Sessions (Dallas, TX).
- (14) "Simulating Optogenetic Control of the Heart," SIAM Conference on Computational Science and Engineering (Boston, MA).
- 2012 (13) "A Computational Framework for Simulating Optogenetically-Engineered Cardiac Tissue," L'Institut de Rythmologie et Modélisation Cardiaque, Université Bordeaux (Pessac, France).
- 2011 (12) "Computational Biophysics and Cardiac Electrophysiology," Libin Cardiovascular Research Institute (Calgary, AB).
- (11) "Why Model the Purkinje System?" Johns Hopkins University (Baltimore, MD).
- 2010 (10) "The Peculiar Purkinje System," Simula Research Laboratory (Oslo, Norway).
- (9) "Ventricular Electrical Synchrony During Simulations of Cardiac Biophysics," INTERFACE: CAMBAM's Industrial Day, McGill University (Montreal, QC).
- 2009 (8) "Role of the Purkinje system in early-stage ventricular fibrillation," SFB Workshop: Methods and Applications of Cardiac Electromechanical Models (Graz, Austria).
- (7) "Computer model investigation of clinical techniques for classifying supraventricular tachycardias," MITACS Annual Conference (Fredericton, NB).
- (6) "Simulating the Atrioventricular Node and an Accessory Pathway in a Ventricular Model," Conference of the Canadian Medical and Biological Engineering Society (Calgary, AB).
- (5) "Hodgkin and Huxley Models: From Simple Equations to Full-Scale Simulations," Master of Biotechnology Program, University of Calgary (Calgary, AB).
- 2008 (4) "Transmission Characteristics at Purkinje-Myocardial Junctions are Affected by Defibrillation-Strength Shocks," Computers in Cardiology Conference (Bologna, Italy).
- (3) "Modelling the Cardiac Purkinje System and its Response to Shocks," Universitat Pompeu Fabra (Barcelona, Spain).

2007 (2) "Behaviour of the Purkinje System During Defibrillation-Strength Shocks," IEEE Engineering in Medicine and Biology Conference (Lyon, France).

(1) "Application of Trellis Coding on the TigerSHARC DSP," University of Calgary (Calgary, AB).

PATENT APPLICATIONS UNDER ACTIVE EXAMINATION BY USPTO

2017 (4) "Using patient-specific modeling of the heart for risk stratification of ventricular arrhythmia in patients with hypertrophic cardiomyopathy via image-based computational simulations," (Provisional Application No. 62/453,917, filed 2017-02-02).

2016 (3) "Using patient-specific modeling of the heart for risk stratification for ventricular arrhythmia in patients with repaired tetralogy of Fallot via image-based computational simulations," (Provisional Application No. 62/417,903, filed 2016-11-04).

2015 (2) "Simulation prediction of targets for catheter ablation of left atrial flutter in patients with atrial structural modeling," (Full specification under review: PCT/US2016/032219, WO2016/183385).

2014 (1) "Systems and methods for atrial fibrillation treatment and risk assessment," (Full specification under review: PCT/US2015/059298, WO2016/077154).

BOOK CHAPTERS

2017 (4) NA Trayanova, **PM Boyle**, "Modeling the Aging Heart," in D Zipes, J Jalife, W. Stevenson (Eds.), *Cardiac Electrophysiology: From Cell to Bedside*, 7e, Philadelphia, PA: Elsevier, ISBN 978-0-323-44733-1.

2015 (3) NA Trayanova, **PM Boyle**, "Cardiac Arrhythmias: Mechanistic Knowledge and Innovation From Computer Models," in A Quarteroni (Ed.), *The Cardio-Circulatory System: from Modeling to Clinical Applications*, Lausanne, Switzerland: Springer International Publishing, ISBN 978-3-319-05229-8.

2011 (2) EJ Vigmond, **PM Boyle**, M Deo, "The Role of the Purkinje System in Defibrillation," in NA Trayanova (Ed.), *Cardiac Defibrillation: Mechanisms, Challenges, and Implications*, Rijeka, Croatia: InTech, ISBN 978-953-307-666-9.

(1) MJ Bishop, HJ Arevalo, **PM Boyle**, NA Trayanova, EJ Vigmond, G Plank, "Cardiac Computational Electrophysiology: Modeling Tissue and Organ," in GS Wagner, O Pahlm (Eds.), *Cardiovascular Multimodal Image-Guided Diagnosis and Therapy*, New York, NY: McGraw-Hill Professional, ISBN 0-071-61346-3.

ABSTRACTS OR PAPERS PUBLISHED IN PEER-REVIEWED CONFERENCE PROCEEDINGS

2018 (40) JK Yu, W Franceschi, Q Huang, **PM Boyle**, NA Trayanova, "Potential mechanisms of cardiac arrhythmia revealed by electrophysiological modeling of cell-based heart repair with pluripotent stem cell-derived cardiomyocytes," *IEEE Eng Medicine Biol Soc*, 2018 (under review).

- (39) M Cartoski, PP Nikolov, **PM Boyle**, PJ Spevak, NA Trayanova, "MRI-based Ventricular Arrhythmia Risk Stratification In Children With Myocarditis," *Heart Rhythm*, 15(5) (accepted).
- (38) C Roney, A Pashaei, M Meo, R Dubois, **PM Boyle**, NA Trayanova, H Cochet, SA Niederer, "Universal Atrial Coordinates For Visualisation, Registration And Construction Of Patient Specific Geometries," *Heart Rhythm*, 15(5) (accepted).
- 2017 (37) A Prakosa, Cartoski MJ, **PM Boyle**, RP O'Hara, F Pashakhanloo, R Coppini, S Pradella, S Zimmerman, MR Abraham, N Maurizi, I Olivotto, NA Trayanova, "Ventricular Arrhythmia in Hypertrophic Cardiomyopathy: Novel Arrhythmia Risk Stratification Using T1 Mapping, Late Gadolinium Enhancement MRI, and Computational Modeling," *Circulation*, 136:(1S), A16889.
- (36) Cartoski MJ, Nikolov P, **Boyle PM**, Spevak PJ, Trayanova NA, "Personalized Risk Stratification for Ventricular Arrhythmia in Pediatric Patients With Myocarditis via Image-Based Computational Simulations," *Circulation*, 136:(1S), A15442.
- (35) **PM Boyle**, S Zahid, WH Franceschi, MJ Murphy, A Prakosa, T Zghaib, M Balouch, EG Ipek, J Chrispin, RD Berger, H Ashikaga, JE Marine, H Calkins, S Nazarian, DD Spragg, NA Trayanova, "Reentrant Drivers of Persistent Atrial Fibrillation Identified by Personalized Computational Modeling Correlate to Rotors Observed Clinically by Intracardiac Mapping: A Pilot Study," *Heart Rhythm*, 14(5):S260.
- (34) JK Yu, WH Franceschi, **PM Boyle**, NA Trayanova, "Electrotonic interactions between ventricular myocytes and injected hiPSC-derived cardiomyocytes increase cardiac ectopy: insights from a 3D human computational model," *Heart Rhythm*, 14(5):S52-53.
- (33) JK Yu, WH Franceschi, **PM Boyle**, NA Trayanova, "Increased clustering of hiPSC-derived cardiomyocyte distribution increases the likelihood of cardiac ectopy: insights from a realistic human model of post-myocardial infarction ventricular tachycardia," *Heart Rhythm*, 14(5):S147.
- (32) MJ Cartoski, M Reymann, P Nikolov, A Prakosa, **PM Boyle**, PJ Spevak, NA Trayanova, "Risk Stratification for Ventricular Arrhythmia in Patients with Hypertrophic Cardiomyopathy via MRI-Based Computational Simulations: A Pilot Study," *J Cardiovasc Magn Reson*, 19:(S1), P213.
- 2016 (31) MJ Cartoski, A Prakosa, P Nikolov, **PM Boyle**, PJ Spevak, NA Trayanova, "Risk Stratification for Ventricular Arrhythmia in Patients With Repaired Tetralogy of Fallot via Image-Based Computational Simulations: A Pilot Study," *Circulation* 134:(1S), A11921.
- (30) **PM Boyle**, S Zahid, EL Schwarz, KN Whyte, EJ Vigmond, R Dubois, M Haïssaguerre, M Hocini, P Jaïs, H Cochet, NA Trayanova, "Emergent Mechanisms Of AF Sustainance After Failed Reentrant Driver Ablation: Insights From MRI-Based Personalized Atrial Models," *Heart Rhythm*, 13(5):S405-6.
- (29) **PM Boyle**, S Zahid, EL Schwarz, KN Whyte, EJ Vigmond, R Dubois, M Haïssaguerre, M Hocini, P Jaïs, H Cochet, NA Trayanova, "Cell And Tissue-Level Changes Resulting From Fibrosis Need To Be Represented In Personalized Atrial Models To Correctly Reproduce Clinical

Outcomes In AF Patients,” *Heart Rhythm*, 13(5):S541–2.

(28) **PM Boyle**, MJ Murphy, RC Blake, S Zahid, TV Karathanos, D Wang, KN Whyte, EL Schwarz, E Entcheva, NA Trayanova, “Optogenetic Termination Of Reentrant Atrial Arrhythmia Could Be Enabled By Localized, Long-Duration, Low Energy Light Pulses Applied Endocardially: A Computational Study,” *Heart Rhythm*, 13(5):S176–7.

(27) S Zahid, **PM Boyle**, EL Schwarz, KN Whyte, EJ Vigmond, R Dubois, M Haïssaguerre, M Hocini, P Jaïs, H Cochet, NA Trayanova, “Machine Learning Identifies Relationship between Reentrant Driver Locations and Fibrosis Spatial Patterns in Patient-Specific Models of Human Atria,” *Heart Rhythm*, 13(5):S370.

(26) S Zahid, **PM Boyle**, EL Schwarz, KN Whyte, EJ Vigmond, R Dubois, M Haïssaguerre, M Hocini, P Jaïs, H Cochet, NA Trayanova, “Reentrant Drivers simulated from MRI-based patient-specific models correlate to drivers mapped clinically with ECGI,” *Heart Rhythm*, 13(5):S297–8.

(25) S Zahid, KN Whyte, EL Schwarz, **PM Boyle**, J Chrispin, RC Blake, A Prakosa, EG Ipek, HR Halperin, H Calkins, RD Berger, S Nazarian, NA Trayanova, “Prediction of Optimal Ablation Targets for Left Atrial Flutter in Patient-Specific Models using the ‘Minimum Cut’ Algorithm,” *Heart Rhythm*, 13(5):S121–2.

(24) JK Yu, T O’Hara, **PM Boyle**, JR Priest, AM Dubin, E Ashley, NA Trayanova, “Mosaic expression of a novel SCN5a mutation (V1762L) in Purkinje cells may underlie 2:1 AV block and left bundle branch block observed in an infant with LQTS,” *Heart Rhythm*, 13(5):S455.

(23) **PM Boyle**, MJ Murphy, TV Karathanos, D Wang, S Zahid, KN Whyte, EL Schwarz, E Entcheva, NA Trayanova, “Pulse Duration Determines Efficacy of Arrhythmia Termination via Targeted Optogenetic Stimulation,” *Biophys J*, 110(3):585a.

(22) JK Yu, **PM Boyle**, T O’Hara, JR Priest, E Ashley, NA Trayanova, “Somatic Mosaicism of Novel SCN5a Mutation in Purkinje System May Underlie 2:1 Block in an Infant with Long QT Syndrome,” *Biophys J*, 110(3):527a.

2015 (21) S Zahid, KN Whyte, EL Schwarz, A Prakosa, **PM Boyle**, B Barcelon, K Fukumoto, J Chrispin, EG Ipek, M Habibi, T Suzuki, HR Halperin, H Calkins, RD Berger, S Nazarian, NA Trayanova, “Feasibility of Using MRI-based, Patient-Specific Simulations to Predict Ablation Targets in Human Left Atrial Flutter,” *Heart Rhythm*, 12(5):S113.

(20) S Zahid, **PM Boyle**, EL Schwarz, KN Whyte, EJ Vigmond, R Dubois, M Haïssaguerre, M Hocini, P Jaïs, H Cochet, NA Trayanova, “Stability of Reentrant Sources and Ablation Targeting in Fibrotic Human Atria with Persistent Atrial Fibrillation,” *Heart Rhythm*, 12(5):S116.

(19) **PM Boyle**, TV Karathanos, D Wang, S Zahid, KN Whyte, EL Schwarz, H Calkins, S Nazarian, E Entcheva, NA Trayanova, “Spatial Distribution of Light-Sensitive Cells and Density of Illumination Sources Determine Effectiveness of Optogenetics-Based Termination of Atrial Fibrillation in a Simulation Study,” *Heart Rhythm*, 12(5):S407–8.

- (18) H Cochet, R Dubois, J Relan, S Zahid, N Aljefairi, S Yamashita, J Sellal, B Berte, S Amraoui, A Denis, N Derval, **PM Boyle**, NA Trayanova, F Sacher, M Hocini, P. Jaïs, “Relationship between rotor activity and fibrosis in persistent atrial fibrillation: a combined noninvasive mapping and MRI study,” *Heart Rhythm*, 12(5):S512.
- (17) TV Karathanos, **PM Boyle**, JD Bayer, D Wang, NA Trayanova, “Opsin Spectral Sensitivity Determines the Effectiveness of Optogenetics-Based Defibrillation,” *Biophys J*, 108(2):148a.
- 2014 (16) S Zahid, **PM Boyle**, P Malamas, F Vadakkumpadan, R Dubois, EJ Vigmond, M Haissaguerre, M Hocini, P Jais, H Cochet, NA Trayanova “Reentrant Sources in Persistent Atrial Fibrillation Are Located in Regions with Specific Spatial Patterns of Fibrosis” *Circulation* 130:(2S), A13235.
- (15) EJ Vigmond, **PM Boyle**, “A Quantitative Validation of the Safety Factor for Cardiac Impulse Propagation,” *Heart Rhythm*, 11(5):S334–5.
- 2013 (14) J Yu, **PM Boyle**, CM Ambrosi, NA Trayanova, E Entcheva, “High-Throughput Contactless Optogenetic Assay for Cellular Coupling: Illustration by ChR2-Light-Sensitized Cardiac Fibroblasts and Cardiomyocytes,” *Circulation* 128:(2S), A14943.
- (13) EJ Vigmond, **PM Boyle**, S Massé, K Nanthakumar, “Activation Rate Gradients During Early VF Are Determined By Transmural $I_{K(ATP)}$ Heterogeneity,” *Heart Rhythm*, 10(5):S253.
- (12) F Campos, Y Shiferaw, A Prassl, **PM Boyle**, EJ Vigmond, G Plank, “Preferred Locations of Calcium-Mediated Triggered Activity,” *Heart Rhythm*, 10(5):S441.
- 2012 (11) **PM Boyle**, JC Williams, E Entcheva, NA Trayanova, “Spatial Distribution of ChR2 Affects Optical Stimulation Efficiency in Cardiac Tissue,” *Heart Rhythm*, 9(5):S182.
- (10) **PM Boyle**, GD Veenhuyzen, EJ Vigmond, “Why Isn’t Fusion During Entrainment of Orthodromic Reciprocating Tachycardia More Diagnostically Useful?” *Heart Rhythm*, 9(5):S325–6.
- (9) **PM Boyle**, JC Williams, E Entcheva, NA Trayanova, “A Computational Framework for Simulating Cardiac Optogenetics,” *Comp Cardiol*, 39:5-8.
- 2010 (8) **PM Boyle**, GD Veenhuyzen, EJ Vigmond, “Computer Simulation of Supraventricular Tachycardias with Pseudo-ECG Recordings,” *Can J Cardiol*, 26, 90D-91D.
- (7) **PM Boyle**, S Massé, K Nanthakumar, EJ Vigmond, “Purkinje-Myocardial Coupling Determines Reentry Type in Simulations,” *Heart Rhythm*, 7(5):S288.
- (6) EJ Vigmond, **PM Boyle**, LJ Leon, G Plank, “Near-Realtime Simulations of Bioelectric Activity in Small Mammalian Hearts Using Graphical Processing Units,” *IEEE Eng Medicine Biol Soc*, 2009, 3290-3.
- 2009 (5) M Deo, **PM Boyle**, G Plank, EJ Vigmond, “Modeling the Effects of Conduction System Disorders on Cardiac Rhythm,” *Heart Rhythm*, 6(5):S419–20.

- 2008 (4) M Deo, EJ Vigmond, **PM Boyle**, G Plank, “Role of Purkinje system in cardiac arrhythmias,” *IEEE Eng Medicine Biol Soc*, 2008, 149-52.
- (3) HA Ghaly, **PM Boyle**, EJ Vigmond, A Nygren, “Reduced conduction reserve of the propagating cardiac impulse in the diabetic rat heart,” *IEEE Eng Medicine Biol Soc*, 2008, 5926-9.
- (2) M Deo, **PM Boyle**, G Plank, EJ Vigmond, “Role of Purkinje System in Arrhythmogenesis and Maintenance,” *Heart Rhythm*, 5(5):S212.
- 2007 (1) **PM Boyle**, M Deo, EJ Vigmond, “Behaviour of the Purkinje System During Defibrillation-Strength Shocks,” *IEEE Eng Medicine Biol Soc*, 2007, 419-22.

SELECTED MEDIA COVERAGE

- “CaMKII-dependent regulation of atrial late sodium current and excitability,” *AJP Heart and Circulatory Podcast* (featured as content expert), 2016/11/02.
- “Super new defibrillator ameliorates prognosis,” *The Economist: Babbage (Podcast)*, 2016/11/02.
- “Optical defibrillator shows promise as a less shocking way to reset your heart,” *Digital Trends*, 2016/09/26.
- “Optogenetic defibrillation,” *JHU promotional video*, 2016/09/19.
- “Future heart defibrillators could save lives with light pulses,” *engadget*, 2016/09/14.
- “Optical defibrillation to soothe arrhythmic hearts,” *Medgadget*, 2016/09/13.
- “Light could replace shock to regulate hearts,” *The Baltimore Sun*, 2013/11/15.
- “Illuminating the Heart—and Helping it to Beat,” *NPR Maryland Morning* (radio), 2013/09/23.
- “New way to treat heart arrhythmia,” *CBC Eyeopener* (radio), 2013/09/09.
- “Researchers study ability of light to restore heart beat,” *The Calgary Herald* (archived), 2013/09/04.
- “The Pacemakers of the Future Will Keep Your Heart Beating With Light,” *VICE Motherboard*, 2013/08/29.
- “Virtual Heart Beats to the Rhythm of the Light,” *medGadget*, 2013/08/29.
- “Scientists shine a light on irregular heart beats,” *c/net Science & Technology*, 2013/08/28.

TEACHING AND MENTORSHIP EXPERIENCE

AT JOHNS HOPKINS UNIVERSITY

- 2017 Doctoral examination committee member for David Hunter, PhD
Thesis: “*Reducing the Pain of Cardiac Electrical Therapies*”
- 2017–now Seminar Instructor for *EN.580.735: Advanced Seminars in Computational Medicine*

- 2016–now Academic curriculum adviser for undergraduate students: Diego Arevalo, Raphael Bechtold, Teya Bergamaschi, Gabriel Fernandes, Nicholas Garza
- 2016–now Co-supervisor for Dongdong Deng, postdoctoral fellow
Project: *Personalized Computer Models to Custom-Tailor Ablation Procedures for AF Patients*
- 2016–now Research Co-Mentor for Ryan O’Hara, pre-doctoral student (Trayanova lab trainee)
Project: *Stratification of arrhythmia risk in patients with hypertrophic cardiomyopathy*
- 2015–now Seminar Instructor for *EN.580.738/739: Advanced Seminars in Cardiac Electrophysiology and Mechanics*
- 2015–now Research Co-Mentor for Joseph Yu, PhD candidate (Trayanova lab trainee)
Project: *Optimization of stem cell therapy to ameliorate cardiac function in post-MI patients*
- 2014–now Research Co-Mentor for Thomas Karathanos, PhD candidate (Trayanova lab trainee)
Project: *Exploration of optogenetics-based alternatives for cardiac arrhythmia treatment*
- 2013–17 Research Co-Mentor for Sohail Zahid, PhD (Trayanova lab graduate)
Project: *Personalization of atrial arrhythmia treatment using patient-derived computational models*
- 2013–now Research adviser for undergraduate students: Jenna Ballard, William Franceschi, Joe Hakim, Qinwen Huang, Michael Murphy, Maximillian Reymann, Erica Schwarz, Kaitlyn Whyte
- 2012–14 Research Co-Mentor for Carolyn Park, MSc (Trayanova lab graduate)
Project: *Arrhythmogenesis in the structurally normal ventricles*

AT UNIVERSITY OF CALGARY

- 2011 Laboratory Instructor for *ENGG225: Fundamentals of Electrical Circuits and Machines*
- 2010 Course Instructor for *BMEN409: Bioelectricity*
- 2009–11 Research adviser for undergraduate students: Paul Coyle, Adarsh Madhavan, Matthew Reid
- 2007–10 Graduate Teaching Assistant for *ENEL341: Introduction to Circuits*, *ENGG407: Numerical Methods*, *ENCM369: Computer Organization*, and *ENEL563: Biomedical Signal Analysis*

AWARDS & ACCOLADES WON BY MENTORED TRAINEES

- 2016 William Franceschi, Provost’s Undergraduate Research Award
- 2015 Erica Schwarz, Provost’s Undergraduate Research Award
- 2014–16 Sohail Zahid, Graduate Fellowship, National Science Foundation
- 2015 Sohail Zahid, Achievement Rewards for College Scientists Scholarship

PEDAGOGICAL TRAINING

- 2014 University Teaching 101: *Coursera* MOOC (Massive Open Online Course), *Johns Hopkins University*
- 2010 Instructional Skills Workshop (4-day training session), *University of Calgary*

PROFESSIONAL SOCIETIES

- 2013–now Fellow, Heart Rhythm Society
- 2013–now Member, American Heart Association
- 2007–now Member, IEEE
- 2005–now Licensed Professional Engineer, APEGA

PROFESSIONAL SERVICE ACTIVITIES

- 2018 Heart Rhythm Society (HRS) Annual Scientific Sessions: *Program Committee Member and Invited Session Chair* (“From Gene to Channel: Biogenesis of the Ion Channel Network and Arrhythmogenesis” and “The Road Less Traveled: Non-Traditional Career Paths in EP”)

University of Calgary Idea Exchange Tour: “From Sci-fi to Reality: The Next Frontier of Medicine,” *Moderator & Session Contributor*.
- 2017 Heart Rhythm Society Annual Scientific Sessions: *Program Committee Member and Invited Session Chair* (“Fibrosis and AF Mechanisms: What’s New,” “Meet-The-Experts: Translational AF Research,” and “The Road Less Traveled: Non-Traditional Career Paths in EP”)
- 2017 Workshop on Mathematical Methods in Cardiac EP: *Session Chair* (“Uncertainty & Estimation”)
- 2016 Heart Rhythm Society Annual Scientific Sessions: *Invited Session Chair* (“Pearls of Wisdom from a Geographically and Scientifically Diverse Group of Experts”)
- 2016 Clin Med Insights Cardiol: *Guest Editor*, focus issue on “Calcium Dynamics and Cardiac Arrhythmia”
- 2016 Mitacs Accelerate: *Expert Reviewer for Research Partnership Proposals*
- 2016–now Heart Rhythm Society Travel Scholarships Working Group: *Member and Application Reviewer*
- 2015–now Heart Rhythm Society Emerging Leaders Community of Practice: *Planning Committee Member*
- 2010–now *Expert Peer Reviewer* of 25+ research papers for several academic journals: Amer J Physiol Heart Circ Physiol, Biophys J, BME Online, Circ Arrhythm Electrophysiol, Comp Biol Med, Europace, IEEE Potentials, IEEE Trans Biomed Eng, Int J Numer Meth Biomed Eng, Med Biol Eng Comput, PLoS One, PLoS Comp Biol, Prog Biophys Mol Biol, Sci Rep, and Trends Cardiovasc Med

LEADERSHIP ACTIVITIES

AT JOHNS HOPKINS UNIVERSITY

- 2017–now Journal Club Coordinator, NIH T32 pre-doctoral training program in Computational Medicine
- 2015–now Marketing Committee Member, Department of Biomedical Engineering
- 2014–now Session Chair, Institute for Computational Medicine Annual Retreat
- 2013–14 Past President and Historian, Homewood Postdoctoral Association
- 2012–13 President, Homewood Postdoctoral Association
- 2011–12 Vice President, Homewood Postdoctoral Association
- 2011–now Journal Club Co-Chair, Computational Cardiology Lab

AT UNIVERSITY OF CALGARY

- 2010–11 Chair, Finance Standing Committee, Graduate Students' Association
- 2009–11 Member, Bylaw Review Committee, Graduate Students' Association
- 2009 Student Activities Coordinator, Canadian Medical and Biological Engineering Conference
- 2008–11 Member, Graduate Representatives' Council, Graduate Students' Association
- 2008–10 President, Electrical and Computer Engineering Graduate Students' Association
- 2006–10 Meeting Coordinator, Bioelectricity Group Weekly Literature Review
- 2006–08 Organizing Committee Member, Alberta Biomedical Engineering Conference
- 2005–06 Member, Finance Standing Committee, Graduate Students' Association
- 2005 Member, Engineering Faculty Promotions Committee
- 2005 Member, Engineering Academic Appointment and Review Committee
- 2004–05 Engineering Faculty Representative, Students' Academic Assembly

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