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American Heart Journal Plus:
Cardiology Research and Practice

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Research paper

Introduction to “Artificial intelligence and health informatics in learning health systems in cardio-oncology”

Sherry-Ann Brown ^{a,b,*}

^a Cardio-Oncology Program, Division of Cardiovascular Medicine, Medical College of Wisconsin, Milwaukee, WI, USA

^b Department of Cardiovascular Diseases, Mayo Clinic, Rochester, MN, USA



ARTICLE INFO

Keywords:

Artificial intelligence
 Learning health system
 Health informatics
 Health equity
 Cardio-oncology

Cardiovascular disease is a leading cause of death among cancer survivors, including adult survivors of childhood cancers, and these patients face a greater risk of cardiovascular disease than the general population [1–3]. Cardio-oncology is a relatively new medical specialty devoted to the detection, prevention, and management of cardiovascular complications associated with cancer or cancer therapy [4]. In the dawn of the digital era, it will be prudent to consider opportunities for the application of various forms of emerging innovation and technologies for the care of cancer patients and survivors. To help lead these endeavors, this manuscript series in the *American Heart Journal Plus* envisioned by Associate Editor Brown and handled by Editor-in-Chief Carl Pepine will give an overview of opportunities for artificial intelligence and health informatics innovation in learning health systems in cardio-oncology.

The first manuscript in this series addresses trends in AI publications in cardiology and in oncology on PubMed, as a backdrop for the manuscripts on opportunities for AI specifically in cardio-oncology at the interface of cardiology and oncology. The second manuscript has a spotlight on artificial intelligence (AI) and electrocardiography in cardio-oncology. The third (and companion to the second) manuscript has an emphasis on artificial intelligence (AI) and imaging in cardio-oncology. Manuscripts in the series also address the pursuit of health equity in digital transformation, health informatics, and the cardiovascular learning healthcare system, and the importance of interdisciplinary learning healthcare system team science in cardio-oncology artificial intelligence and health informatics initiatives. Some of these

manuscripts are highlighted here below.

1. Trends in cardiology and oncology artificial intelligence publications

AI is a burgeoning research area that promises to continue to lead the science and healthcare fields towards a path of high performance, especially in the cutting-edge fields of cardiology and oncology. There have been increasing amounts and pace of published research in AI, signaling increasing interest and applications in these fields. Objective evidence on the accelerated growth of AI in these fields is provided, particularly in the last five years since around 2015 [9]. Continued subsequent exponential growth is predicted, based on these historical trends.

2. Artificial intelligence opportunities in cardio-oncology: overview with spotlight on electrocardiography

For over half a century, ECG parameters such as QRS amplitude/duration and QT interval have been evaluated and found to associate with (and perhaps predict) systolic dysfunction. Additionally, in the past handful of years, artificial intelligence algorithms applied to ECGs (AI-ECG) have been used to predict cardiomyopathy and arrhythmias, among other conditions. Yet, no one has written specifically about applying AI-ECG in Cardio-Oncology. Seminal papers on AI-ECG in Cardiology and the role of ECG parameters in cardio-oncology are

* Corresponding author at: Cardio-Oncology Program, Division of Cardiovascular Medicine, Medical College of Wisconsin, 8701 Watertown Plank Road, Milwaukee, WI 53226, USA.

E-mail address: shbrown@mcw.edu.

<https://doi.org/10.1016/j.ahjo.2022.100156>

Received 27 May 2022; Accepted 14 June 2022

Available online 17 June 2022

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highlighted [5].

3. Artificial intelligence and imaging: opportunities in cardio-oncology

A spotlight is also shed on opportunities for the application of artificial intelligence methodologies to imaging modalities in cardio-oncology. AI technologies applied to cardiovascular imaging in cardio-oncology with a strong emphasis on prevention and tailored treatment could be helpful for a variety of cardiovascular conditions for cancer patients. The use of AI-augmented echocardiography, cardiovascular magnetic resonance imaging (CMR), computed tomography (CT; especially coronary artery calcium (CAC)), single proton emission computed tomography (SPECT) and positron emission tomography (PET) imaging acquisition and analysis for prediction and assessment of cardiovascular adverse events in patients treated for cancer are proposed. AI-augmented multimodality imaging is described for assessment of intracardiac tumors based on the currently emerging reports predicting utility in the general and cardio-oncology populations. The opportunities for application of AI in Cardio-Oncology imaging are great, and if availed, could become a game-changer for our patients. This article highlighting seminal papers on and the role of AI in imaging applied to Cardio-Oncology may be useful to others in the field [6].

4. Connected Health Innovation Research Program (C.H.I.R.P.): A Bridge for Digital Health and Wellness in Cardiology and Oncology

The Connected Health Innovation Research Program (C.H.I.R.P.) is an interdisciplinary research platform that aims to advance this field through innovation, patient education, and improved care delivery systems supplemented by digitalhealth. A connected health research program was developed to evaluate the adoption and clinical efficacy of digitalhealth products for wellness and cardiovascular health in the future. De-identified retrospective data on specific clinical outcomes have been gathered through these partnerships for retrospective studies on adoption, clinical efficacy, and user satisfaction, prior to pursuing prospective and case studies. A user-friendly set of tools for patient care, engagement, education, and outcomes was created, with the goal of improving overall health and cardiovascular health, particularly in cardio-oncology [10]. Company technologies focus on wellness biometrics tracking, oxygen saturation, weight trends, sleep patterns, heart rate variability, AI diagnostics, electrocardiogram/blood pressure patterns and their integration into electronic health records, audio companions with curated sessions, real-time metabolism tracking, and instructional video modules. The cardio-oncology community now has access to a collection of software and hardware innovations; a website is currently in testing, and a mobile application is in the planning stages.

5. The pursuit of health equity in digital transformation, health informatics, and the cardiovascular learning healthcare system

In comparison to Caucasians, African Americans have a higher risk of cardiovascular morbidity and death, as well as a lower rate of specialty consultation and treatment. In the management and treatment of chemotherapy-related cardiovascular problems, there are substantial discrepancies. Cardiotoxicity affects African Americans at a higher incidence than it does Caucasians, and they are underrepresented in clinical trials aiming at reducing cardiovascular harm caused by cancer treatments. An integrative and innovative approach will be necessary to reduce racial and ethnic differences in cardiotoxicity prevention. If implemented carefully and strategically in conjunction with minority populations, several forms of digital transformation using health informatics have the potential to contribute to health equity [8].

6. Establishing an interdisciplinary research team for cardio-oncology artificial intelligence informatics precision and health equity

Predicting cardiovascular risk in individuals with a history of cancer and cancer treatment, on the other hand, is difficult. Thus, it was determined that establishing an interdisciplinary team to develop cardiovascular risk stratification clinical decision aids that will be integrated into oncology patients' electronic health records was critical. This manuscript emphasizes the need for and describes the process of building a successful interdisciplinary research team focused on leveraging artificial intelligence and informatics and provides initial output on an epidemiological cohort for cardio-oncology studies developed by the multi-institutional team. The team's core members from MCW, UWM, and MSOE, as well as additional team members from Cleveland Clinic, Mayo Clinic, and other institutions, have joined forces to advance cardio-oncology through the use of high-performance computing. The team is comprised of clinicians and researchers from a variety of complementary fields relevant to this work. In the article, lessons learned in establishing this team are presented, as well as preliminary findings from the epidemiology cohort [7].

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We are grateful to Editor-in-Chief Carl Pepine for approving and serving as the handling editor for this innovative and timely article series. We are also grateful to Abdulaziz Hamid for reading this manuscript. This publication was supported by the National Center for Advancing Translational Sciences, National Institutes of Health, through Grant Numbers UL1TR001436 and KL2TR001438. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NIH.

Author contributions

Conception and design: SAB.
 Drafting of the manuscript: SAB.
 Interpretation of data: SAB.
 Critical revision: SAB.
 Final approval of manuscript: SAB.

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