

Invited Editorial for: Artificial Organs

Title: OpenHeart Project – An Open-Source Research Community in the Field of Mechanical Circulatory Support

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Running Title

OpenHeart Project

Introduction

The objective of this editorial is to introduce the OpenHeart Project, an open-source research platform and community in the field of mechanical circulatory support (MCS), to researchers, laboratories and companies undertaking MCS related research. Furthermore, the authors feel that the OpenHeart Project may be relevant for the broader research community, as its approach could be easily adopted in other research fields.

Background

Heart failure (HF) is a global pandemic affecting more than 26 million people worldwide, and its prevalence is only increasing as the population ages [1,2]. In 2012, HF was responsible for an estimated health expenditure of \$31 billion (equivalent to more than 10% of the total health expenditure for cardiovascular diseases in the USA), and total costs are expected to increase by 127% by 2030 [1]. The gold standard treatment of end-stage HF is heart transplantation; however, in 2016 only 7,089 transplantations were performed worldwide (2016 data are based on the Global Observatory on Donation and Transplantation (GODT) data, produced by the WHO-ONT collaboration) [3]. Thus, the use of mechanical circulatory support (MCS) in the management of acute and chronic HF is continuously expanding. Even though the use of MCS is rapidly growing and the US National Institute of Health estimates 50,000-100,000 patients in the USA alone could immediately benefit from MCS, the risk profile and associated complications (i.e. bleeding, infections, cardiac arrhythmias and stroke) limits the widespread use of these devices [4]. Ergo, too many HF patients succumb to their condition. There is a clear need for improved research outcomes in the field of MCS.

It has been reported that an estimated 85% of all global research resources (not only in the field of MCS) are currently wasted due to false and non-reproducible results or slow and potentially inefficient translation of knowledge into useful applications [5–7]. Risk factors for high rates of false results are: flexibility in study designs, definitions and analyses and a lack of collaboration between researchers [5]. Adoption of large-scale collaborative research with a strong replication culture has been successful in several biomedical fields (e.g. genetic and molecular epidemiology) [8]. Sharing of data, protocols, materials and other resources has been promoted in other fields, creating a foundation for reproducible research practices [9–11]. Meanwhile, improvements in study design standards can improve the reliability of research results, while improved training and continuing education of researchers is also important [12,13].

The research field of MCS and the International Society for Mechanical Circulatory Support (ISMCS - along with kindred learned societies e.g. ASAIO, APSAO, ESAO, IEEE EMBS, JSAO) consists of researchers from multiple international research laboratories, universities, and companies scattered around the globe. Research is often undertaken in isolation within each laboratory, limiting inter-laboratory collaboration and thus limiting the full potential of the field of MCS. For example, too many good research projects come to an abrupt halt on graduation of the PhD candidates who were conducting those projects. There is a clear need and untapped potential for improved collaborative efforts, improved education and

standardisation and subsequent improvement of research quality and outcomes within the field of MCS.

Aims & Objectives

The OpenHeart Project is an open-source research project which aims to improve research practices and outcomes within the field of MCS to ultimately improve outcomes and quality of life for heart failure patients around the globe. This will be achieved through ISMCS and other artificial organs societies, many of which have overlapping membership with ISMCS and each other. Key objectives of the OpenHeart Project are:

- To promote improved collaboration and standardisation within the field of MCS through implementation of an open-source online research platform.
- To leverage the existing resources, data and expertise within ISMCS and other societies through open data sharing. Especially we aim to give a second life to PhD projects that would otherwise have languished in university archives and to make these available to industry.
- To improve education and training of students and emerging researchers within the field of MCS through development of free online courses, tutorials and training tools.

Structure

Key entities of the OpenHeart platform are the OpenHeart website (www.openheartproject.org), data repositories, MCS Wiki and networking capabilities. The OpenHeart website is the point of first contact for researchers interested in the project and provides information about the background, aims and progress of OpenHeart. Through the website researchers are able to join the OpenHeart community.

Networking capabilities, MCS wiki and data repositories are implemented using the software solutions Stride, Confluence and Bitbucket (Atlassian Corporation Plc, Sydney, Australia). Embedded networking capabilities - Stride - provides the opportunity to propose collaborations and projects between participating researchers, laboratories, companies, universities, international standards organisations and regulators as well as to raise and discuss current research questions.

The foundation for the MCS wiki is implemented within Confluence as a knowledge base especially for PhD candidates and early career researchers. Within the wiki the most common terms in the field, equations and information can be defined and expanded on by the community. Collating this background information in one space, under the guidance and approval of senior researchers in the field of MCS, will improve the education of students and emerging researchers in the field of MCS around the globe. Furthermore, standardized protocols for study designs, experimental set-ups, data acquisition and data analyses can be presented within the MCS wiki. Furthermore, a free massive open online course (MOOC) is under development along with other educational and training tools (e.g. practical tutorials, interactive maps and animations) – interested parties are invited to participate in writing the MOOCs.

The core entity for sharing data within the MCS community are the open-source data repositories hosted within Bitbucket, which allows researchers to create unlimited

repositories to upload and share their data. Specifically, current and former PhD candidates are invited to share their data to give PhD projects a second life rather than languishing in university or laboratory archives. Information to be shared may include (but is not limited to): numerical and CFD models for *in silico* experiments, designs of mock circulation loops and pump test rigs for *in vitro* experiments, code for improved patient monitoring and physiological control systems, unsuccessful ideas, and raw data that could not be included in a peer-reviewed publication. Artificial Organs will provide the opportunity to link to OpenHeart repositories (and thus raw data) for existing and future publications. OpenHeart members are able to freely upload and download files and comment directly on uploaded content. Built-in version control within Bitbucket allows for efficient tracking of changes made to individual repositories. All source code and software within the repositories are licensed under the BSD-3-Clause license while all other data are licensed under a common creative license (CC BY V4.0). Under these licences all material shared within OpenHeart will become open-source, thus it is important that you own the copyright in the material you submit or have permission or the rights from the copyright owners prior to submission. It is free to share, copy and redistribute the material in any medium or format as well as free to adapt, remix, transform and build upon the material for any purpose as long as the license terms are followed. Researchers must give appropriate credit, provide a link to the license and indicate if changes were made. This can be done in any reasonable manner, however, not in any way that suggests the licensor endorses you or your use.

Value proposition

Through active participation within the OpenHeart Project, students and researchers will have the opportunity to shape a new generation of research within the field of MCS. They will be able to showcase their research and know-how through the creation of data repositories and content within the MCS wiki, while being able to interact with their peers within the OpenHeart community. By sharing existing solutions (e.g. experimental set-up, equipment design, data analysis strategy) it will be possible to save research time and money while giving emerging researchers a head start. It is hoped that commercial entities in the MCS space will become familiar with the OpenHeart Project and will look to connect with researchers and projects on the platform

Who is involved?

The OpenHeart Project to date has been a collaboration amongst Griffith University, The University of Queensland, the Innovative Cardiovascular Engineering and Technology Laboratory (ICETLAB) and Critical Care Research Group (CCRG) within the Prince Charles Hospital and Monash University – but it is ready to roll out to the world. To gain worldwide support for the OpenHeart Project, ISMCS has adopted and supports the project. Other support is given by The Common Good (www.thecommongood.org.au/projects/openheart) and The Prince Charles Hospital Foundation.

Call for action

An open-source project like OpenHeart can only thrive through active participation of its community members, thus we would like to invite everyone interested or working in the field of MCS to join the OpenHeart community. To join, please visit the OpenHeart website (www.openheartproject.org) and fill out the join form. An OpenHeart account will then be created for you. As you might expect, sponsors are also sought!

Conclusion

In conclusion, an open-source online platform (OpenHeart) has been created to improve collaboration, standardization, education and data sharing within the field of MCS. The structure is implemented through existing software solutions and researchers are able to join the community and create content. Networking capabilities and MCS wiki are the two key entities to achieve improved collaboration and standardization within the field of MCS, while improved education and training will be achieved through online lecture series (MOOCs) and MCS wiki. Data sharing will be facilitated through the creation of data repositories. The aim is to improve the overall research quality and outcomes within the field of MCS. The OpenHeart community needs to grow and more content still needs to be created, while educational tools are still under development. The authors encourage our research community to join the OpenHeart Project.

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