Advanced Perioperative Imaging Laboratory (APIL) Annual Report 2019-2020

Dr. Azad Mashari

Over the past year, the APIL team consisted of 5 anesthesiologists (Drs. Mashari, Moreno, Ng, Vegas and Dinsmore), 7 research staff (Jo Carroll, Joshua Qua Hiansen, Vahid Anwari, Kate Kazlovich and Samareh Ajami, with assistance from Nour Ayach and Saba Ansari for Covid related projects), 2 clinical anesthesia fellows (Lembrikov, Schiavo), 1 University of Toronto Medical Student (Ryan Ramos), 2 International Medical Students from Bahrain (Moshira Mahran, Nawal Almohammad) and 1 undergraduate student from Ryerson University (Sachin Khargie).

APIL's activities since March 2020 have focused almost exclusively on development and manufacturing of medical devices related to the COVID-19 pandemic.

Medical device development, evaluation and manufacturing

Since March 2020 APIL has been actively involved in a number of device development and manufacturing projects, in collaboration with Glia Inc, an open source medical device development company; U of T Department of Mechanical and Industrial Engineering; as well as several private sector partners. Projects include: reusable faceshields (manufacturing in compliance with HC regulations; A reusable N95 respirator (empirically validated; regulatory approval pending); aerosol reducing non-invasive ventilation mask (HC IO approved; FDA EUA pending) ; safe, individually tailored, ventilator splitting system (testing and manufacturing of 80 systems); High-acuity, low-operability emergency ventilator (complete prototype); A PAPR mask created from a modified snorkel mask (Development and manufacturing 200 devices for internal use at UHN; 50 complete); a 3D printed adapter to connect HME filters to 3D elastomeric respirators (quantitative validation in progress). This work has been funded through four UHN/SHS AMO COVID 19 Fund grant ($ 375,000), an NSERC Alliance Grant ($50,000), and a Grant from Ontario Centres of Excellence ($ 60,000) and support from The Toronto General and Western Hospital Foundation.

Patient specific surgical modelling for procedural planning

Our clinical services consist of creation of patient-specific 3D models from medical imaging data, in order support patient education and planning of complex surgical and minimally invasive procedures. In the past year we continued to create models to guide complex minimally invasive structural and electrophysiological heart disease interventions. In addition we were involved in creating a model of a complex cardiac tumor for open resection. We also created our first procedural planning model for the Division of Orthopedics at UHN. A major barrier to extending our clinincal services has been the lack of suitable financial infrastructure. This barrier has now been surmounted and we now have a clinical service account that will allow recuperation of operational costs from departments requesting models.

Perioperative imaging / modelling validation and translation to practice

Our work includes studies to evaluate the feasibility and validate the accuracy of workflows for creating 3D digital and printed models of normal and pathological mitral and aortic valves. The MV project compared all currently available software packages for 3D MV modeling against a reference standard of manual measurements (Manuscript in preparation). The AV project evaluated the accuracy

of 3D segmentation and printing of the aortic root models using proprietary and open source software against a reference standard of manual measurements (Manuscript in preparation).

Three observational studies currently in the initiation stage evaluating the effects of hyperbaric oxygen therapy on biventricular systolic and diastolic function (with Dr. Rita Katznelson); the prognostic value of RV systolic and LV diastolic function indices on outcomes after kidney and liver transplant (with Dr. Stuart McCluskey).

Educational simulation

The Toronto Heart Atlas developed in collaboration with the division of cardiology and cardiac surgery and the joint department of medical imaging currently includes over 23 whole heart models based on cardiac CT covering a variety of adult congenital heart diseases. We have developed a custom 3D viewer for the atlas which is now stored at APIL's own website (https://apil.ca/toronto-3d-heart-atlas/).

In addition we continue to develop our procedural phantoms which are customized to specific curriculum objectives and created in collaboration with educators from across the faculty of medicine. Projects currently include: Subclavian Vascular Access Phantom (with Dr. Sharon Peacock, SHS) and a Transesophageal Echocardiography Phantom which we have been developing over the past 4 years. The first deliverable version of this has now been completed and a validation study has been published (Meineri M et al. Evaluation of a Patient-Specific, Low-Cost, 3-Dimensional-Printed Transesophageal Echocardiography Human Heart Phantom. J Cardiothorac Vasc Anesth. 2020 Jul 6) In addition we have continued to refine our high fidelity on-line echocardiography simulator with normal and ACHD hearts https://apil.ca/echocardiography-simulator/

APIL is currently developing a high volume image-interpretation module that will allow trainees to evaluate a large volume of normal and abnormal echocardiography clips, with feedback, in a short amount of time. Using machine learning and predictive modelling the system will customize the sequence and repetition rate of questions to optimize the exposure for each user. The initial prototype is for FOCUS cardiac ultrasound but will eventually be expanded to more advanced echocardiographic image interpretation.

Infrastructure and funding

To date APIL has provided 29 patient-specific models that have been used for planning of complex minimally invasive procedures but this service has been limited to the divisions of cardiology and cardiac surgery. In collaboration with the Joint Department of Medical Imaging (JDMI), The Techna Institute and the Surgility Program and the Department of Surgery, APIL has been working to develop infrastructure for making 3D modelling and printing services available to all UHN clinicians. With support from JDMI, APIL has developed pricing models and projections for resource requirements. All necessary infrastructure is now in place, however the launch of the service has been delayed due to Covid 19 pandemic.