References

1. Lo Rito M, Romarowski RM, Rosato A, Pica S, Secchi F, Giamberti A, et al. Anomalous aortic origin of coronary artery biomechanical modeling: toward clinical application. *J Thorac Cardiovasc Surg*. 2021;161:191-201.e1.
2. Jegatheeswaran A, Devlin PJ, Williams WG, Brothers JA, Jacobs ML, DeCampli WM, et al. Outcomes following anomalous aortic origin of a coronary artery repair: a Congenital Heart Surgeons' Society Study. *J Thorac Cardiovasc Surg*. April 13, 2020 [Epub ahead of print].
3. Mery CM, DeLeon LE, Molossi S, Sexson-Tejtel SK, Agrawal H, Krishnamurthy R, et al. Outcomes of surgical intervention for anomalous aortic origin of a coronary artery: a large contemporary prospective cohort study. *J Thorac Cardiovasc Surg*. 2019;155:305-19.

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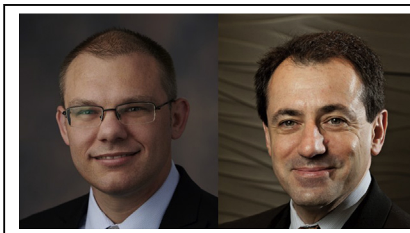
Commentary: Anomalous coronary arteries and car crash testing

Jacob R. Miller, MD, and Pirooz Eghtesady, MD, PhD



Jacob R. Miller, MD, and Pirooz Eghtesady, MD, PhD

CENTRAL MESSAGE

Structural finite element analysis allows for the dynamic evaluation of an anomalous coronary arteries. It may, eventually, help determine if surgical intervention is necessary.

An anomalous right coronary artery from the left coronary sinus (AAORCA) that is incidentally discovered, or even those with vague symptoms, continues to pose a conundrum.[1-3] Surgical outcomes, in terms of short-term survival, are excellent.[4] However, recent reports note worsening ventricular function, aortic valve function, or even death in a very small number of patients undergoing surgery for an anomalous coronary, even asymptomatic patients.[5] Therefore, a better understanding of who will benefit from surgical intervention is necessary to avoid surgery when the anatomy is unlikely to cause pathology. Currently, this decision is largely based on cross-sectional imaging. These current imaging modalities are insufficient, as they obtain static images and of the patient at rest. In this issue of the *Journal*, Lo Rito and colleagues[6] attempted to address these problems. Building off their earlier work using finite element analysis (FEA), recognizing that the aortic root and coronaries are dynamic, they created a model replicating the loading conditions associated with activity.[7]

FEA is used to evaluate the impact of a force on a complex structure. To do this, the structure is broken down into a finite number of elements. A simulation is run evaluating the strain on each element based on the force applied. When the elements are reassembled, the impact on the entire structure can be inferred. Commonly, it is used in the simulation of motor vehicle accidents. The car is broken down into multiple elements, each with different properties. The force of an impact on each element is evaluated, and they are reassembled and the damage to the automobile and its occupants determined.

Similarly, the authors divided the aortic root and coronaries (including their ostium and intramural course) into a finite number of elements. Using FEA simulations, the models were inflated at a baseline pressure and 2 greater pressure loads to simulate modest and strenuous activity. For each, the cross-sectional area of the coronaries was evaluated every 0.5 mm. This was performed for 10 patients, 5 controls and 5 with AAORCA. For patients with AAORCA, the model demonstrated that the normally arising left coronary appropriately increased in cross-

From Washington University in St Louis School of Medicine/St Louis Children's Hospital, St Louis, Mo.

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Address for reprints: Pirooz Eghtesady, MD, PhD, St Louis Children's Hospital, One Children's Place, Suite 5 South, St Louis, MO 63110 (E-mail: eghtesadyp@wudosis.wustl.edu).

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sectional area similar to controls, whereas the anomalous right did not. At maximum loading conditions, the anomalous right demonstrated only an 8% increase in cross-sectional area, compared with 19% in controls. A more modest, yet significant, difference occurred at lower loading conditions. In addition, although a small sample size, the only 3 patients who were symptomatic demonstrated the least expansibility.

In these simulations, the patient's aortic wall is not replicated, as well as other potential elements that could be contributory, including any factor distal to the aortic root. For example, the pulmonary artery is omitted, neglecting a potential contributor to the pathophysiology. Certainly, much remains before this approach gains clinical applicability. Despite this, the authors are to be congratulated on their study. It pushes the field in the right direction, evaluating these lesions in a dynamic fashion. Only by visualizing the coronaries in "real time" will we be able to identify the at-risk population.

References

1. Brothers JA, Frommelt MA, Jaquiss RDB, Myerburg RJ, Fraser CD Jr, Tweddell JS. Expert consensus guidelines: anomalous aortic origin of a coronary artery. *J Thorac Cardiovasc Surg*. 2017;153:1440-57.
2. Poynter JA, Williams WG, McIntyre S, Brothers JA, Jacobs ML, Congenital Heart Surgeons Society AAOCA Working Group. Anomalous aortic origin of a coronary artery: a report from the Congenital Heart Surgeons Society registry. *World J Pediatr Congenit Heart Surg*. 2014;5:22-30.
3. Jegatheeswaran A, Devlin PJ, McCrindle BW, Williams WG, Jacobs ML, Blackstone EH, et al. Features associated with myocardial ischemia in anomalous aortic origin of a coronary artery: a Congenital Heart Surgeons' Society study. *J Thorac Cardiovasc Surg*. 2019;158:822-34.
4. Frommelt PC, Sheridan DC, Berger S, Frommelt MA, Tweddell JS. Ten-year experience with surgical unroofing of anomalous aortic origin of a coronary artery from the opposite sinus with an interarterial course. *J Thorac Cardiovasc Surg*. 2011;142:1046-51.
5. Jegatheeswaran A, Devlin PJ, Williams WG, Brothers JA, Jacobs ML, DeCampli WM, et al. Outcomes following anomalous aortic origin of a coronary artery repair: a Congenital Heart Surgeons' Society Study. *J Thorac Cardiovasc Surg*. 2020;160:757-71.e5.
6. Lo Rito M, Romarowski RM, Rosato A, Pica S, Secchi F, Giamberti A. Anomalous aortic origin of coronary artery biomechanical modeling: toward clinical application. *J Thorac Cardiovasc Surg*. 2021;161:191-201.e1.
7. Formato GM, Lo Rito M, Auricchio F, Frigiola A, Conti M. Aortic expansion induces lumen narrowing in anomalous coronary arteries: a parametric structural finite element analysis. *J Biomech Eng*. July 23, 2018 [Epub ahead of print].