Bicuspid aortopathy: Seeing the forest for the trees

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Central Message

Machine learning identified the bicuspid aortic valve to be associated with 3 aorta aneurysm phenotypes: root, ascending, and arch. Machine learning is a valuable tool for clinical research.

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Readers of the *Journal* will find interest in this article on machine-learning phenotype classification of bicuspid aortopathy.¹ The authors' premise is that the link between aortic morphology and valvular pathology has been incompletely characterized. This is a nicely written article that provides "seeing the forest for the trees" with respect to patterns of aortic dilatation in patients with bicuspid aortic valve. My appreciation of the article was enhanced with review of additional reading materials about machine learning and cardiovascular imaging.²

The focus of this study was to determine whether machine learning methods could discern distinct phenotype patterns of bicuspid aortopathy and then to associate the phenotype patterns with visual rules that could be recognized in computed tomography/magnetic resonance imaging (CT/MRI). The data included imaging analysis of 656 CT/MRI scans with cross-sectional diameter measurements taken at the level of the sinuses of Valsalva, sinotubular junction, tubular ascending aorta, proximal aortic arch, and midaortic arch. Measurements were standardized for body surface area. Imaging studies were subsequently re-reviewed in a blinded fashion and the visual and machine learning classifications compared.

Through a series of rather complex analyzes using unsupervised clustering algorithms, machine learning identified the bicuspid aortic valve to be associated with 3 phenotypes of aortic dilatation: (1) root (ie, aorta at the sinuses of Valsalva was larger than at the tubular ascending aorta), (2) ascending (ie, aorta at the origin of the brachiocephalic artery was smaller than at the sinotubular junction), and (3) arch (ie, aorta at the origin of the brachiocephalic artery was equal to or larger than at the sinotubular junction). Concordance with visual classification was 94%.

The concept of 3 phenotypes of bicuspid aortic dilatation was previously introduced in a 2014 review article by Verma and Siu.³ Wojnarski and colleagues make the point, however, that the review article was the authors' interpretation of available literature and that no referenced study recognized all 3 phenotypes. I find the main strength of the present article to be an unbiased confirmation, based

on unsupervised machine learning methodology, of Verma's and Siu's patterns of bicuspid aortic dilatation. In essence, Wojnarski and colleagues provide an "it is what it is" validation of the 3 phenotypes of bicuspid aortopathy.

The main weakness of the article is a perceived selection bias. This is a retrospective analysis of patients who underwent ascending aorta surgery, and, as such, the article does not provide any data or analysis of patients who did not undergo operation. Furthermore, image analysis relied on the largest aorta cross-sectional diameter, and that may not be the best measure of size (eg, query use of area in the transcatheter aortic valve insertion experience).^{4,5} Finally, CT/MRI images were assessed at a single point in time. The authors point out that identifying the true relationship between ascending aorta phenotypes will require longitudinal data.

It is my impression that the concept and analysis presented in this article affirms the potential of machine learning in clinical research. In the present analysis, machine learning confirmed human learning.

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