The authors reported no conflicts of interest.

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CAN WE TALK? THE RESIDUAL, URGENT QUESTIONS ABOUT SURGERY FOR CORONARY ARTERY ANOMALIES

To the Editor:

This letter refers to an important recent review by one of the most active pediatric surgical centers for treating coronary artery anomalies (CAAs).[1] Our own Center believes this review calls for an open discussion from an alternative, adult cardiology source that is dedicated to treating the same congenital anomalies.

The comprehensive and welcome report by Bonilla-Ramirez and colleagues,[1] which describes their admirable experience with 71 consecutive pediatric patients during 2012 to 2019, is illuminating in stating the current rationale for and practices in the field of surgery for coronary anomalies. Our group would like to add some essential aspects of related current investigations, as observed from alternative viewpoints and up-to-date diagnostic/interventional techniques.[2,3] A reconciliation is urgently required across unjustifiable borders.

GENERAL ISSUES

The authors[1] describe their experience with all the CAAs of origin that they corrected surgically. Their implication seems to be that any kind of anomalies of the right and left coronary arteries are part of a single anatomic, functional, prognostic, and surgical entity, here discussed as a unit. In reality, many types of coronary anomalies are possible, and they vary in clinical relevance and severity. In particular, this approach favors the tendency to improvise and construct hypotheses without a proper, comprehensive discipline. In contrast, we believe that the individual anomalies' features are substantially different (especially in their symptoms and mortality) and must be reported and discussed separately, by the specific anomaly's type and severity. We now know[4] that about 1,300,000 people are born in the United States with certain specific kinds of clinically important anomalies. All anomalies of origin with intramural course (IM, with dynamic lateral compression and variable stenosis) should be differentiated from others, like prepulmonic, intraseptal, retroaortic, and retrocardiac, that are generically benign.[2-5] Initially, in our judgment, adequate and accurate routine screening is generally necessary only in high-risk populations such as athletes (in whom sudden cardiac death can be the first symptom), which adds to the congenital high-risk anatomy the important risk factor of strenuous exercise, as discussed in depth in recent updates.[2,3] The significance of having a refined notion of the population-based prevalence of the different CAAs relates to understanding the global importance of the high-risk entities. In young athletes, for example, establishing the need for intervention requires one first to know the real incidence of high-risk CAAs (the denominator of the risk factor) and that of sudden cardiac death during strenuous exertion. Eventually, the value of competing interventional treatments will be revealed by comparisons between medical versus any plausible interventional treatment modalities.

In this regard, we and many other authors use currently a more refined and expressive nomenclature for this pathology than what the generic, global term "anomalous aortic origin of a coronary artery (AAOCA)" implies.[4,5] To begin with, we believe that any given CAA can be better described as anomalous right or left (R- or L-) coronary artery origin from the opposite or improper sinus (ACAOS) with the addition of a term describing the artery's course from the ectopic origin toward the dependent territory (-intramural [-IM] is the course that is most likely to cause secondary functional impairments). This terminology can individually identify the implied mechanisms of possible dysfunction or the generic absence thereof. The authors[1] do not report the incidences of R-ACAOS-IM and L-ACAOS-IM cases separately, as they should have done, nor do they mention IS course, about which they recently published separately an important report.[6] (These anomalies would also be considered AAOCA.)

DIAGNOSIS

The preoperative diagnostic evaluation of a case of ACAOS should identify not only its general type (in a qualitative sense) but also the individual case's quantitative stenotic severity (stenosis being the general mechanism of action of a coronary pathology). Echocardiography, computed axial tomography angiography (CTA), and even coronary catheter angiography cannot reliably assess fixed or dynamic stenosis severity with respect to the distal refence vessel, which is the fundamental reason to treat ACAOS cases surgically. The only precise methods for quantitative evaluation of dynamic narrowing are intravascular ultrasonography (IVUS) and optical coherence tomography, which are not used routinely by many pediatric cardiology centers, even those specialized in caring for

patients who will undergo CAA surgery (even though they indeed use intracoronary pressure wires, as recently reported[6]).

Both symptoms and stress-testing are neither precise nor sensitive.[2,3] Magnetic resonance angiography and CTA are adequate for qualitative diagnosis of ACAOS but not for quantitative study of severity in individual cases. In particular, CTA imaging is usually limited to end-diastole, when the severity of stenosis is lowest during the cardiac cycle, in these dynamic IM-stenoses. (Systole increases lateral compression because of pulsatile distention of the aortic wall.[2,3]) Also, exercise increases the systolic stenosis severity substantially by increasing cardiac output, stroke volume, and systolic time (leading to maximal functional stenosis, which also varies with aortic root elasticity in individual cases). By IVUS imaging, stenosis severity at rest in cases of ACAOS-IM (initially, qualitatively diagnosed by CTA) varies between 20% and 90% (or 30%-100% with saline–atropine–dobutamine testing,[2,3] in systole). Such diagnostic evidence is an essential diagnosis for indicating surgical intervention in ACAOS-IM cases.

TREATMENT

The authors' experience[1] apparently depends frequently on surgical findings, which unfortunately cannot be used to establish cross-sectional stenosis precisely and objectively (which also requires the distal reference cross-sectional area) to serve as a valid parameter for indicating a surgical procedure that is already in progress. As a consequence, for example, 37% of initial unroofing cases were eventually changed to ostial reimplantation.[1] Especially in cases of R-ACAOS-IM in older patients, IVUS-guided stent-angioplasty (not mentioned in Bonilla and colleagues' article, but widely reported by contemporary adult cardiologists[2,3]) is probably a much simpler, safer, and more reliable solution when performed at expert centers that are trained and active in addressing the specific indications for this procedure. Also, during the IVUS-monitored stenting procedures, the results are confirmed immediately after stenting. Obviously, the utility and safety of stent treatment must be evaluated in prospective controlled studies at coordinated and dedicated centers of excellence and compared with the established surgical experience. Late restenosis when using drug-eluting stents in R-ACAOS-IM is less than in coronary atherosclerotic disease (occurring in about 1 in 28 cases of drug-eluting stent placement, or 3.57% at 5-year follow-up) and is not accompanied by late lateral stent-compression, as the experience from our current total of 50 cases confirms. In our own 2015 report on percutaneous coronary intervention for R-ACAOS-IM, the total number of stent angioplasties was 42 (in patients aged 12-73 years, mean 48 years). All patients had moderate or severe symptoms and a cross-sectional area stenosis by IVUS of more than 50% at diastole with a short mean cross-sectional diastolic diameter of 1.3 mm at baseline.[3] Two initial-phase patients, out of 4 who received bare-metal stents, resulted in early restenosis (treated successfully with balloon angioplasty), and only 2 of the 38 drug-eluting stents had restenosis (making the restenosis rate 5.26% at a mean follow-up of 5 years). No author has yet published long-term results from large series, as would be ideal for fair comparisons with surgical results (which are also not available in an accurate, prospective, and detailed fashion). Sometime in the future, controlled and prospective multicenter studies of PCI versus surgical procedures for R-ACAOS-IM cases will become available. Early results show that PCI is effective in relieving stenosis and symptoms, producing results similar to what surgical procedures can yield. A direct comparison of PCI and surgery will also be useful for reporting the nature and severity of the IS anomaly (especially of L-ACAOS-IS), on which the authors did not report, as would be expected in a paper on AAOCA.[1,6]

We hope these short notes, proposed in the spirit of information-sharing/updating and professional collaboration, can promote a more logical and effective, integrated treatment paradigm to treat ACAOS (-IM, in particular).

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References

1. Bonilla-Ramirez C, Molossi S, Sachdeva S, Reaves-O'Neal D, Masand P, Mery CM, et al. Outcomes in anomalous aortic origin of a coronary artery after surgical reimplantation. *J Thorac Cardiovasc Surg*. 2021;162:1191-9. https://doi.org/10.1016/j.jtcvs.2020.12.100
2. Angelini P, Uribe C. Anatomic spectrum of left coronary artery anomalies and associated mechanisms of coronary insufficiency. *Catheter Cardiovasc Interv*. 2018;92:313-21.
3. Angelini P, Uribe C, Monge J, Tobis JM, Elayda MA, Willerson JT. Origin of the right coronary artery from the opposite sinus of Valsalva in adults: characterization by intravascular ultrasonography at baseline and after stent angioplasty. *Catheter Cardiovasc Interv*. 2015;86:199-208.
4. Angelini P, Cheong BY, Lenge De Rosen VV, Lopez A, Uribe C, Masso AH, et al. High-risk cardiovascular conditions in sports-related sudden death: prevalence in 5,169 schoolchildren screened via cardiac magnetic resonance. *Tex Heart Inst J*. 2018;45:205-13.
5. Angelini P, Muthupillai R, Lopez A, Cheong B, Uribe C, Hernandez E, et al. Young athletes: preventing sudden death by adopting a modern screening approach? A critical review and the opening of a debate. *Int J Cardiol Heart Vasc*. 2021;34:100790.
6. Doan TT, Zea-Vera R, Agrawal H, Mery CM, Masand P, Reaves-O'Neal DL, et al. Myocardial ischemia in children with anomalous aortic origin of a coronary artery with intraseptal course. *Circ Cardiovasc Interv*. 2020;13:e008375.

https://doi.org/10.1016/j.xjon.2022.04.027