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EDITORIAL COMMENT

3-Dimensional Printing

A Hype or a Necessity?*

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Primary tricuspid valve disease affects a very heterogeneous group of patients. Patients with carcinoid valves have little in common with patients with 1 or more leaflets entangled in pacemaker leads, or patients with post-traumatic tricuspid regurgitation (TR). Despite numerous causes of tricuspid valve disease, this group of patients remains small (1).

The tricuspid valve and the tricuspid annulus are challenging to image conventionally. However, 3-dimensional (3D) imaging is quite a significant improvement from 2-dimensional echocardiogram resolution. When treating mitral valve tricuspid valve disease, whether surgically or percutaneously, there are 2 main features to analyze: the lesion and the dysfunction. The dysfunction may be well quantified by echocardiogram, showing TR severity and right ventricular dysfunction, if present. However, in some instances the lesion is not easy to identify precisely by echocardiogram even when using 3D imaging (2). The use of 4-dimensional (4D) computed tomography (CT) as adjunct imaging represents a step forward in helping to define the lesion, as illustrated in this issue of *JACC: Case Reports* by Harb et al. (3), in their series of 4 cases. For instance, when pacemaker leads restrict 1 or more leaflets, it is often impossible echocardiographically to identify where and how this restriction happens: 4D CT may provide the answer. Similarly, although prolapse of 1 leaflet may be identified by echocardiogram, the precise location and extension of the prolapse may be difficult to detect. In such cases, 4D CT imaging brings further accuracy and may show the lesion precisely.

The use of 3D printing offers a complementary modality, allowing whoever is involved to make an accurate in situ appraisal of the lesion. The 3D printing and 3D virtual valvular reconstruction made possible by licensed or open-source create an easily implemented decision-making tool. The type of 3D printer depends on the degree of model complexity that is necessary (e.g., diverse material rigidity in a single printed prototype). Some of these printers are very costly and are currently available only in tertiary centers. As mentioned by Harb et al. (3), we should embrace every opportunity to optimize pre-operative planning, tailor the procedure to anticipate anatomic pitfalls, shorten the operative time, and improve post-operative patient outcomes.

Experienced surgeons have seen hundreds of tricuspid valves and many various disorders, unlike trainees, nurses, or patients who have been not exposed to the pathophysiology of these conditions and may be confused when looking at conventional imaging. Every surgeon may find 3D printing somewhat helpful, although surgeons with experience in tricuspid valve repairs will already have seen similar lesions and, on surgical exposure of the tricuspid valve, will determine the appropriate technique to treat a given lesion, such as restoring free edge chordal support in cases of chordal rupture, using an autologous pericardium patch to repair an endocarditic leaflet perforation, or removing trapped pacemaker leads and restoring leaflet integrity or chordal support if needed.

In contrast, trainees with little or no experience may find that 3D printing helps them to understand

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the lesion better and to suggest therapeutic options. It may even become mandatory for young surgeons to train using 3D printing (4), much as pilots train on simulators throughout their careers. Similarly, patients may see and understand exactly what their disease is, understand more clearly what their surgical procedure will require, and thereby decrease their anxiety.

The concept of 3D printing, however interesting, seems less relevant to surgeons than to interventional cardiologists, especially when treating secondary TR. Most interventional cardiologists have never seen a tricuspid valve or performed a tricuspid repair. Their understanding is therefore limited to imaging and dysfunction rather than lesions (5). The increasing use of tricuspid valve clipping reflects this statement because most cases of secondary TR are related to annular dilatation and would be best addressed using percutaneous annuloplasty. In some instances, however, especially for long-standing severe secondary TR, there may some degree of tethering that is clearly not addressed by annuloplasty alone (surgically or percutaneously) and could also require clipping of the tricuspid valve. MitraClip (Abbott, Abbott Park, Illinois) seems to be quite efficient for the mitral valve, but its tool for the tricuspid valve does not seem to provide similarly good results (6). The results are being assessed on the degree of regurgitation decrease, which represents the dysfunction. The complex anatomy and the anatomic variation of the leaflet size and motion make clipping of the tricuspid valve far more difficult. Most likely, adding in an appraisal of the tricuspid valve and identification of the target lesion would help to improve outcomes of percutaneous procedures. In patients with TR, 3D printing could also be useful for secondary TR assessment before percutaneous treatment.

By providing relevant information, 3D printing of the tricuspid valve could become a decision-making tool for the heart team when choosing which treatment is better for a given patient.

Surgeons and cardiologists alike would benefit from improved imaging and spatial resolution of a such a complex apparatus as the tricuspid valve, and 3D printing could be a valuable tool for this purpose.

AUTHOR DISCLOSURES

Dr. Dreyfus has reported teaching courses for Edwards Lifesciences. Dr. Dulguerov has reported that he has no relationships relevant to the contents of this paper to disclose.

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