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EDITORIAL COMMENT

3-Dimensional Printing in Personalized Interventional Cardiology and Cardiac Surgery*

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Currently, cardiologists and cardiac surgeons have to manage highly individual pathology on a much larger scale compared with the past because we are increasingly confronted with pre-operated patients presenting with combined acquired entities as well as with adults who survived with congenital heart disease (CHD) after surgery in childhood, meaning that conventional 2- and 3-dimensional (3D) imaging alone is not always sufficient for conceptualization anymore (1,2), even if a lot of progress has been made in that area during the last decades. Pre- and peri-interventional visualization for therapy of structural heart disease (SHD) was relegated to flat screen representations (3) although, particularly before highly complex procedures, conventional 3D imaging is not as effective as having a physical model identical to the patient's anatomy (4). As a result, 3D printing, also known as "modeling," has emerged and evolved into a transformative technology in cardiovascular medicine and surgery (5). It represents "materialized" 3D imaging rather than an autonomous technique. Based on 3D image data derived from computed tomography, magnetic resonance imaging, or echocardiography, it requires procedural steps such as segmentation and conversion into Standard Tessellation Language files complemented by fixing and design, which are needed to create those datasets compatible with a 3D printer. Various 3D printing techniques (e.g., stereolithography, selective laser sintering, binder jetting, PolyJet technology (Materialise Inc., Leuven, Belgium), and fused deposition modeling) differ significantly in quality, time required, and procedural costs (2).

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In this issue of *JACC: Case Reports*, Elmaghraby et al. (6) reported a case demonstrating all the advantages of 3D printing for the optimization of spatial conceptualization before any specific therapy. Modeling was performed with the authors' intention-to-treat, even though the patient finally did not undergo cardiac surgery. Nevertheless, impressive 3D casts shown in their article presage an enormous potential inherent to this technology. It facilitates communication with the medical team and patient's family as well as education and procedural training (1,2).

For cardiovascular surgeons, actual anatomic structures may be unpredictable because of great variety of morphology in patients with SHD and CHD despite excellent conventional pre-operative imaging. Thus, peri-operative planning and decision making in those cases considered complex and nonroutine require spatial anatomic orientation, which cannot be easily extrapolated from medical experience (7). Models of any cardiovascular structure can be sterilized and directly taken into surgery. Life-like replicas of valves and their surroundings of congenital and acquired malformations help decision making for choosing an individual treatment strategy (e.g., minimizing the surgical access sites) and support intraoperative orientation. Displaying spatial dimensions of defects and other pathology one-to-one facilitates corrective surgery and eventually

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accelerates the procedure (2). Benefits of peri-interventional 3D printing have been reported for transcatheter aortic valve replacement, percutaneous mitral valve repair, and device closure of an atrial septal defect and left atrial appendage (2). Models can be used for test runs before atrial septal defect and left atrial appendage device implantation in order to select appropriate catheters and device size.

In conclusion, 3D printing may help to optimize peri-operative and peri-interventional management of SHD in general and of CHD in particular. The costs of 3D printing and lacking cost absorption by health insurances remain limitations. The fact that the technique did not yet find its way into current guidelines represents another downside.

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