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Custom Fenestration Templates for Endovascular Repair of the Aortic Arch

Ludovic Canaud, MD, PhD[1], Thomas Gandet, MD[1], Baris Ata Ozdemir, FRCS, PhD[1], Lucien Chassin-Trubert, MD[1], and Pierre Alric, MD, PhD[1]

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In the October 2018 issue of the *JEVT*, Rynio and colleagues[1] report the utility of a 3-dimensional (3D) printed template of the aortic arch in the construction of a fenestrated and scalloped physician-modified stent-graft (PMSG). The technique was successfully demonstrated in a patient with an aortic arch aneurysm.

Several centers have published encouraging results using branched stent-grafts for the aortic arch.[2–4] However, there are increasing numbers of elderly and frail patients who fall outside of device sizing specifications or who need a more urgent repair (symptomatic, rapidly enlarging, or contained ruptured aneurysm or dissection) with off-the-shelf technology that has yet to become widely available. Furthermore, some physicians have limited or no access to manufactured devices because of regulatory issues or cost.

The frequency of reports citing the use of physician-modified thoracic stent-grafts is increasing.[5,6] These modified thoracic stent-grafts are indeed very useful and should be part of the armamentarium of any vascular surgeon dealing with complex aortic lesions. Wide dissemination of this approach is not easy to achieve. In addition, acquisition of the precise methodology by which devices are modified requires a somewhat gradual learning curve. There are a number of important limitations that should be taken into consideration when deciding to treat a thoracic lesion with a PMSG. First and foremost, there is no quality control when making modifications to a device. There are potential inaccuracies in measurements, risk of contamination, and alteration of the integrity of the device.

The evolution of radiographic imaging has facilitated improvements in the preparation and planning of the surgical approach. With the rapid advancement of cross-sectional imaging in the last decade, high-resolution 3D images can routinely be obtained that help in the visualization of complex vascular anatomy. However, even with this progress, the 3D image is still limited to viewing on a 2D screen.

With 3D modeling, the individual complexities of a patient's anatomy can be seen and felt at every angle. Medical 3D printing produces models of anatomical structures from volumetric datasets, typically from imaging; these models enable visual inspection of human anatomy and pathology and direct manipulation of the structures. Although the technology has been available for more than 30 years, this decade has heralded exponential growth and interest in the integration of this new "modality" in the clinical arena. Device selection and stent-graft delivery for endovascular aneurysm repair can be improved by 3D printing,[7] particularly for complex aortic aneurysms.[8]

These models allow the surgeon to better understand the patient's anatomy. Patient-specific 3D-printed fenestration templates for modification of endovascular grafts to be used in aortic arch aneurysm can expedite planning and theoretically reduce risk of potential inaccuracies in measurements. Templates based on an individual patient's anatomy provide a simple and accurate guide for on-site construction of graft fenestrations, so it is possible to fabricate perfectly fitting devices if required. Moreover, being able to hold a model in one's hand and examine it from different sides allows the surgeon to develop the optimal interventional approach and to anticipate difficulties that may arise. The dimensions and distances can be easily identified, and interventions or surgical procedures can be planned and simulated preoperatively.

The limitation of the proposed model is that aortic anatomy may change after the insertion of a semirigid stent-graft

[1]Department of Thoracic and Vascular Surgery, Arnaud de Villeneuve Hospital, Montpellier, France

Corresponding Author:
Ludovic Canaud, Service de Chirurgie Vasculaire et Thoracique, Hôpital A de Villeneuve, 191 av Doyen Gaston Giraud, 34090 Montpellier, France.
Email: ludoviccanaud@hotmail.com

into the aortic lumen and thus alter the alignment of the side branches. This same issue is valid for custom-made devices and other PMSGs that are based on computed tomography angiography measurements.

Despite the promise that medical 3D printed models hold, widespread use of 3D printing in the clinical setting is still limited by lack of robust and quantitative evidence demonstrating its effectiveness, workflow complexity, and costs associated with design and 3D printing. As the technology continues to develop, 3D printing has the potential to revolutionize the future of medicine. Its current clinical applications can be expanded through streamlining the 3D printing process, reducing costs, and increasing access.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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