Transcatheter aortic valve replacement (TAVR) is a treatment for aortic stenosis in patients who are inoperable or have high risk for surgery [1,2]. Since the first in-man TAVR was performed in France in 2002, this procedure has been practiced for 10 years, and over 50,000 patients received valve implantation in more than 40 countries [2,3]. The PARTNER Trial showed the survival rate of patients after TAVR and Surgery was similar at 1 year, and TAVR resulted in a significantly lower mortality rate than standard medical therapy [4,5].

Currently, the two types of valves available on the US market are the SAPIEN valve and the CoreValve. SAPIEN is a cobalt-chromium balloon expandable stent with four diameter (20 mm, 23 mm, 26 mm, and 29 mm) options [1]. The size of catheter sheath ranges from 18 Fr to 22 Fr. The valve has three identical leaflets made from bovine pericardium. Bovine pericardium has superior intrinsic biological properties including high collagen content and large water retention [6]. The tissue is fixed in glutaraldehyde to preserve flexibility and strength [2]. In contrast to the SAPIEN valve, the CoreValve uses a self-expanding nitinol (a nickel-titanium alloy) frame, and it comes with four diameters of 23, 26, 29, and 31 mm [1,2]. A 18 Fr sheath fits all valve sizes. Instead of using bovine tissue, the leaflets of the CoreValve are made of porcine pericardium, which has thinner tissue, higher tensile strength, less fragile to bending, and more consistent valve leaflet coaptation [2]. Compared to bovine pericardium, the downside of porcine pericardium tissue is its acute thrombogenicity shown by retaining more platelets on the valve surface [7]. Due to the shape memory property of nitinol, the CoreValve can be deployed in multiple stages for precise position adjustments, and can even be retrieved back to the shaft of the delivery catheter before the stent is entirely deployed. On the contrary, the SAPIEN valve is fully deployed at once with a single balloon expansion, and does not allow repositioning. Regarding procedural outcome, both valves have different post-procedural complications. The self-expanding nitinol creates a higher radial force after deployment. When the nitinol frame is pressing on the adjacent left bundle branch, it adversely damages the His bundle [8]. Consequently, the CoreValve leads to twice more incidents in the placement of pacemakers [5,9]. On the other hand, the SAPIEN valve uses larger sheath size (18 Fr - 22 Fr) than the Core Valve (18 Fr only), resulting in higher vascular complications occurred on its delivery path [5,9].

Another common problem of TAVR is paravalvular leak due to incomplete annular sealing [3]. Paravalvular leak may be caused by implanting a smaller valve, by partial expansion of stents, or by the sealing cuff not positioning against the aortic annulus. Since one of the ways to minimize paravalvular leak is avoidance of choosing undersized valves, measuring the precise diameters of aortic annulus becomes a key. CT or MRI will be more suitable for this purpose than Transesophageal Echocardiography (TEE).

In order to minimize the aforesaid complications, several second-generation valves are either under commercial development or in clinical studies [3]. To allow for repositioning and retraction, most of them (e.g. SADRA Lotus valve) use self-expanding nitinol frame [10,11], and Direct Flow valve is the only non-metallic bioprosthesis that is still repositionable and retrievable [12]. Several designs have been developed to achieve anatomically correct positioning and to minimize paravalvular leak. For example, Enager valve has supporting arms [13], and JenaClip has positioning feelers and novel leaflet fixation mechanism [14]. Among these designs, Acurate valve has shown to lower the rate of paravalvular leaks in short-term patient outcomes [15,16]. Some designs are to minimize atrioventricular conduction block (Portico valve) [3,17], or to treat degenerative bioprosthesis valve disease (Inovare valve) [18,19].

Despite the improvement on the second-generation valves, there are still limitations. For instance, the most commonly used nitinol frame can cause late stent fracture. Besides, aortic injury and atheroembolism occur by reposition of valves [3]. Future direction of valve design will aim at solving these issues. In addition, new devices will be miniaturized to reduce vascular complications, and embolic distal protection device will be used to prevent aortic plaques or thrombotic lesions from travelling to brain vessels to cause major stroke events [1,2]. Since TAVR procedures are rarely emergent, using a 3D printer to customize a stent frame for precise sealing of each patient’s annulus may be an option in the future.
REFERENCES