An Efficient Way to Make a Trileaflet Conduit for Pulmonary Valve Replacement

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Pulmonary regurgitation after repair of tetralogy of Fallot has always been an important issue for pediatric cardiac surgeons. Some of the patients may need pulmonary valve replacement in the future. Conventional prosthetic valves were seldom custom made for the pulmonary valve and were often inadequate to use because of variable age and size of these patients. Through evolution of techniques, we have developed a simple, efficient, and theoretically anatomic way of constructing trileaflet polytetrafluoroethylene valved conduit used for right ventricle outflow tract reconstruction. It was surprisingly straightforward, time efficient, and capable of being produced in various sizes.

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As a tertiary referring center for pediatric cardiac disease, we have encountered the majority of young patients in Taiwan who required surgical corrections. Reconstruction of the right ventricular outflow tract (RVOT) using extracardiac conduits made of homografts or xenografts has not guaranteed long-term durable results owing to inevitable fibrocalcified degeneration [1]. Furthermore, the lack of homografts due to ethnic concerns in Taiwan and the unavailability of customized pulmonary valves have urged us to use synthetic materials, such as expanded polytetrafluoroethylene (ePTFE) [Gore-Tex; W. L. Gore & Assoc, Newark, DE]. We describe our experience with handmade ePTFE trileaflet conduit through initial design and evolutionary modification over the years. In addition to its near-anatomic composition and lessened suture length compared with other ePTFE designs, we believe it provides an outstanding smooth anchor contour for future transcatheter pulmonary valve implantation.

Technique
Initially, an appropriate ePTFE vascular graft (Gore-Tex Stretch vascular graft) is chosen according to the patient’s RVOT size (usually 18 to 24 mm in diameter). It was cut longitudinally and spread out like a sheet to facilitate valve suturing. The trileaflets are trimmed over a thin ePTFE membrane (0.1 mm in thickness [Gore-Tex Perclose pericardial membrane]) by anatomic semilunar cusp design (Fig 1A). The width of each leaflet is basically
one third of the circumference of the graft and the height is approximately \( \frac{\sqrt{3}}{2} \) of the width (about 0.87 in proportion). An additional 1 mm of length was added to each end of the trileaflet piece for space needed during overlapping suture. The connecting junctions between each leaflet are approximately 3 to 5 mm in height to allow better leaflet coaptation. The trileaflet piece is sutured to the spread vascular graft by first fixing the seven points and then continuously sutured along the semilunar margin by using 6-0 polypropylene or CV-6 Gore-Tex sutures (Fig 1B). The vascular graft is then rolled back and sutured to form a cylindrical-shaped valved conduit (Fig 1C).

Through the years, we have come up with an evolutionary modification of this procedure: by not cutting and spreading the vascular graft, we just suture the trileaflet piece onto the outer surface of the cylindrical vascular graft using the same principle, with six fixation points needed this time (Fig 2A). To overcome the softness and to ease manipulation of the graft, we put a weighted no. 20 Hegar dilator inside during suturing. The finished graft is then flipped inside out to make the valves appear inside the tube (Fig 2B). This modification has saved time with fewer sutures and provided an even smoother and lower resistance conduit. Figure 3 illustrates the three plication suture points we put on the graft (midway between each commissure) to create a sinotubular junction that can facilitate valve closure.

**Comment**

Valved reconstruction of the RVOT has been evolving with different material for decades. First, biological valves such as porcine valves have been implanted and popular long before the 1980s [2]. Another choice is allografts, which have been widely accepted in certain regions and are believed to be superior to xenografts [3]. Drawbacks, however, in addition to limited life duration, are that xenografts can be bulky and inadequately sized to use and allografts have a limited source in different world regions. Researchers have been developing valved conduits made of heterologous pericardium since 1985, with three generations of leaflet materials including porcine, equine, and bovine pericardium [1], which eventually turned out to be unsatisfactory due to an inflammatory and fibrocalcification response by the human body to animal tissue. In recent years, those researchers and many others have been adapting totally artificial valved conduits made of ePTFE, a newer material used in medicine that impedes cellular infiltration and subsequent fibrocalcifications and yet provides longevity [1, 4-6].

Contemporary handmade ePTFE trileaflet conduits are well designed but are often more sophisticated [6] and therefore more technically demanding [7]. Compared to those, our design is easier to understand, is time

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**Fig 2.** (A) A total of six fixation points P were made around the tubular graft before continuous suturing and final appearance of the modified graft. (B) Modified procedure (“no cut and turn inside out” method with top and bottom views in the lower panel).
efficient to reproduce (it takes about 20 minutes) as it has the least suture length of all, and also provides good anatomic valve competence. The other advantage we observed is its one-piece graft composition that can avoid possible graft leakage of multiple-piece connections. Although not clinically proved, composite grafts using ePTFE membrane as valve leaflets have been prone to get stuck open because of insufficient closure mechanism [8]. The reason we made plication sutures at the sinus of Valsalva position was to create a sinotubular junction and thereby enhance the vortex flow between the leaflets and the graft wall that would facilitate leaflet closure. So far we have implanted the modified handmade trileaflet valves with intact conduits in 15 patients over the past 2 years. All of them were performed without difficulties. The follow-up echocardiograms revealed no graft dysfunction.

Many newer therapies, including stent-deployed valves and tissue-engineered homografts, are developing but still do not perfectly meet the needs of repeated pulmonary valve replacement for grown congenital heart disease patients. The thin ePTFE leaflet design in our graft, we believe, can be seamlessly adhered to the graft wall and provides a smooth contour to anchor the stent-deployed valve in the future.

References