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Transapical Mitral Implantation of the Tiara Bioprosthesis

Pre-Clinical Results

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Objectives This study sought to describe the pre-clinical evaluation of transapical mitral implantation of the Tiara (Neovasc Inc, Vancouver, British Columbia, Canada) valve in preparation for first-in-man implantation.

Background The Tiara is a transcatheter self-expanding mitral bioprosthesis, specifically designed for the complex anatomic configuration of the mitral apparatus.

Methods Tiara valves were implanted in a short-term porcine model, in a long-term ovine model, and in human cadavers.

Results Short-term and long-term evaluation demonstrated excellent function and alignment of the valves, with no left ventricular outflow tract obstruction, coronary artery obstruction, or transvalvular gradients. Long-term evaluation of 7 sheep demonstrated clinically stable animals. A mild degree of prosthetic valve regurgitation was seen in 2 of the 7 sheep. A mild-to-moderate degree of paravalvular leak, which was attributed to this animal model, was observed in 6 of these animals. Cardioscopy and macroscopic evaluation demonstrated stable and secure positioning of the Tiara valve with no evidence of injury to the ventricular or atrial walls. Pericardial leaflets were free and mobile without calcifications. Implantation of the Tiara valves in human cadaver hearts demonstrated, upon visual inspection, proper anatomic alignment and seating of the valve, both at the atrial and at the ventricular aspects of the native mitral apparatus.

Conclusions In preparation for the first-in-man transcatheter mitral valve implantation, we report the successful pre-clinical evaluation of the Tiara transcatheter self-expanding mitral bioprosthetic valve. In porcine and ovine models without mitral regurgitation, transapical mitral implantation of the Tiara valve is technically feasible and safe, and results in a stable and well-functioning mitral bioprosthesis. (J Am Coll Cardiol Intv 2014;7:154–62) © 2014 by the American College of Cardiology Foundation

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Severe mitral regurgitation (MR) is commonly associated with dilation of the heart and advanced coronary artery disease, ultimately resulting in disability and death from congestive heart failure. Although surgery remains the gold standard treatment for MR, approximately one-third of potential candidates are considered to be at too high risk for surgical repair or replacement (1–3). Severe MR affects approximately 2% of the population, but its prevalence increases to 13.3% among patients 75 years of age or older in industrialized countries. With advances in medicine enhancing longer survival, the incidence of severe MR is expected to rise dramatically (4).

Various novel percutaneous transcatheter valvular technologies have emerged as alternatives to open surgery for high-risk patients (5). These technologies are classified according to the part of the heart that is being targeted: the leaflets—percutaneous leaflet plication, leaflet coaptation, or radio-frequency leaflet ablation; the annulus—indirect annuloplasty through the coronary sinus, or direct annuloplasty either true percutaneous or by a hybrid approach through the left atrium; the chordae—percutaneous chordal implantation; or the left ventricle (LV)—percutaneous LV remodeling. The percutaneous edge-to-edge repair technology has been shown to be noninferior to open repair in randomized clinical trials. However, percutaneous mitral valve repair is not possible for many patients, and therefore, mitral valve (MV) replacement may be an attractive alternative (5,6). Several transcatheter MV implantation technologies, either transapical or transseptal, are in various stages of pre-clinical evaluation (7–9).

The Tiara (Neovasc Inc, Vancouver, British Columbia, Canada) is a catheter-based self-expanding mitral bioprosthesis, specifically designed to fit the complex anatomic structure of the mitral apparatus. It is implanted using a transapical approach. The valve assembly is shaped to match the natural orifice of the mitral valve and minimize obstruction of the LV outflow tract (10). We describe here the pre-clinical assessment of the Tiara valve in short-term and long-term animal models, as well as in human cadaver hearts, performed as part of the preparation for the planned first-in-man transapical mitral implantation (TAMI).

Methods

Valve properties. The Tiara bioprosthetic valve is fabricated using cross-linked bovine pericardial tissue leaflets mounted inside a self-expanding metal alloy frame and crimped onto a short, flexible 32-F delivery catheter for transapical delivery (Fig. 1). A retractable sheath retains the valve in place until deployment. The atrial portion engages the area of the left atrium surrounding the mitral annulus, and a series of anchoring structures actively engage the mitral leaflets and chordae within the LV, securing the valve from retrograde dislodgement during systole. During all stages of valve implantation until the final release and deployment, it is possible to recapture the partially deployed valve and retrieve it into the delivery catheter, reposition, and restart the implantation process. Tiara implantation, orientation, and alignment was performed under simultaneous echocardiographic and fluoroscopic guidance using a specific radiopaque set of markers on the nitinol frame and on the delivery system.

Tiara implantation protocols. The animal protocols were approved by the Montreal Heart Institute's Animal Care and Use Committee, and the animal care and use committee of the Institute Mutualiste Montsouris Recherche, Paris, France. The protocol for human cadaver trials was approved by the Seattle Science Foundation, Seattle, Washington.

Transapical implantation of the Tiara bioprosthesis was performed by a multidisciplinary team including 2 interventional cardiologists, a cardiac surgeon, and an echocardiographer, through a small subxyphoid incision. The atrial portion of the Tiara (the atrial "skirt") is deployed first so that the flat aspect of the prosthesis frame is oriented anteriorly to align with the D-shaped mitral annulus, followed by deployment of the ventricular portion of the prosthesis that anchors behind the native anterior and posterior mitral leaflets (Fig. 2).

Abbreviations and Acronyms

LV = left ventricle/ventricular
MR = mitral regurgitation
MV = mitral valve
PVL = paravalvular leak
TAMI = transapical mitral implantation

Under general anesthesia and mechanical ventilation, a small subxyphoid incision (<5 cm) was performed exposing the LV apex to allow apical puncture. One orthogonal U-shaped (purse string) suture was placed around the apical entry site. Unfractionated heparin (100 IU/kg) and lidocaine (1 mg/kg) were administered intravenously before apical cannulation. After apical puncture and sheath insertion, a 6-F pigtail catheter and a J-tipped 0.035-inch guide wire were inserted and then advanced across the mitral apparatus into the left atrium. Following removal of the pigtail catheter, the Tiara bioprosthesis, loaded in its delivery system, was advanced over the guidewire and positioned in the left atrium. Upon angiographic and echocardiographic confirmation of proper central positioning within the mitral planes, the guidewire was removed. Tiara implantation began with deployment of the atrial skirt to fit the D-shaped mitral annulus so that the flat aspect of the prosthesis frame was aligned with the LV outflow tract and the aorta. Accurate alignment and engagement of the flat aspect of the Tiara bioprosthesis with the anterior side of the mitral annulus was directed by echocardiography and guided by fluoroscopy utilizing special radiopaque markers on the metal frame of the prosthetic valve. Once aligned and seated on the atrial side of the mitral annulus, the ventricular portion of the prosthesis was deployed and anchored behind the native anterior and posterior mitral leaflets. Immediately