THE LILLEHEI-NAKIB* HEART VALVE

LOW PROFILE reduces outflow tract obstruction and protrusion into the ventricle, particularly important in cases of mitral stenosis with a small left ventricle.

LIGHTWEIGHT TITANIUM TOROID and short excursion promotes better postoperative healing by lessening suture line stress.

TITANIUM CONSTRUCTION reduces thrombus formation, obviates abnormal noise, and has extremely good wearability.

CAGE DESIGN offers minimum restriction to flow, excellent hemodynamics, minimizes turbulence and areas of stagnation.

UNIFORM RESPONSE of lightweight toroid allows the orifice areas to be completely exposed with minimal excursion and greater flow for less cardiac work.

* A.A. Nakib, Ph. D., M.D., inventor of the valve while at the University of Minnesota Medical Center, Minneapolis, Minnesota, under the direction of C. Walton Lillehei, Ph.D., M.D. (U.S. Patent No. 3,438,394)

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THE TOROIDAL (Lifesaver) CONCEPT

Ahmad A. Nakib, M.D. of Beirut, Lebanon conceived the toroidal heart valve with the assistance of Dr. R. Ferlic and Mr. R. Kaster while working in the cardiovascular surgical research division at the University of Minnesota Medical Center, Minneapolis, under the direction of Dr. C. Walton Lillehei.

The toroidal design provides flow both around the periphery and through the center of the valve toroid thus reducing obstruction to blood flow and areas for stagnation. The toroid was designed according to hemodynamic principles to reduce turbulence and to eliminate nidus areas as well as to lower the pressure gradient measured across the valve. The portions of the valve which project into the bloodstream are teardrop designed to provide the best hemodynamic conditions.

SUTURE COLLAR

The present prosthesis uses a suture collar designed for placement at the mitral site. The low profile obviates left ventricular outflow tract obstruction and ventricular arrhythmias which result from the cage of a high profile prosthesis abutting the ventricular septum; also, prompt ventricular filling is aided by the bifurcated flow pattern. Present materials for mitral prostheses collars are Teflon® (U.S. Cath. & Inst. Co.) with a Silastic® (Dow Corning Co. MDX 4-4514) filler to give desired shape and body to the cuff. The cuff design* developed with the assistance of Dr. C.W. Lillehei and his surgical research staff eliminates hazards to the snagging of suture needles when the sutures are placed in cuff, yet allows a very soft suturable and pliable structure. This design has been used successfully clinically since June, 1969, with no detectable problems to date.

VALVE HOUSING

The valve housing is machined from pure medical grade titanium. The open end cage of the weldless uni-body structure is formed by fixture rolling the ends of the four struts to permanently capture the toroid occluder. Stagnation areas are held to a minimum within the housing by using a concave-convex symmetry throughout.

TOROID OCCLUDER

The solid titanium occluder has a convex inflow-outflow symmetry. Malfunctioning (wedging, strut rubbing, sticking, lodging of the toroid occluder) in any position is eliminated by the use of convex surfaces throughout. This design characteristic minimizes the occluder size, which in turn reduces its obstruction to flow. During diastole (when valve is closed) the occluder seals at its outer periphery allowing minor retrograde flow through the central hole which provides a minor backwash to the center teardrop area. Titanium possesses the excellent qualities of structural longevity, lightweight and proven high resistance to biodegradation.

Titanium has:

1. Atomic weight: 47.90
2. Specific gravity: 4.5 @ 17.5°C.
3. Density of commercially pure medical grade titanium is 0.163 lbs. per cu. in.

*F.W. Child patent pending
For single valve replacement, a right posterolateral thoracotomy through the bed of the fifth rib is preferred. The exposure is greatly facilitated if a firm roll, sufficient to produce some hyperextension of the thorax, is placed under the patient's left side positioned directly under the incision. The patient also is positioned so that the level of the incision is centered over the kidney rest. After going on bypass the kidney rest is elevated, further improving the exposure. This same incision also gives excellent exposure to the tricuspid valve. After the appropriate cannulations and institution of total cardiopulmonary bypass, the heart is fibrillated electrically before it is opened to obviate any possibility of air embolism.

For double valve exposure (aortic and mitral), a midline sternotomy is utilized with a transverse atriotomy across right and left atria and septum.

For single valve replacement, the mitral valve is exposed through a longitudinal left atriotomy just posterior to the interatrial groove. The diseased valve tissue is excised leaving a 2 - 3 mm remnant of the patient's own valve tissue. Care is taken to remove sufficient calcium, chordae, and papillary muscle tips to prevent any possibility of projecting tissue from interfering with free movement of the toroid and its snug seating against the titanium rim of the valve housing.

Prosthetic placement is facilitated initially by placing four key sutures equidistant about the anulus — one at each commissure and one at the midpoints between (Figure 1). With gentle traction applied to two adjacent sutures, excellent exposure of each quadrant of the anulus is provided. We have preferred to use horizontal mattress sutures of double armed 2-0 Teflon-impregnated-Dracon. Each suture has been threaded previously through an 8 mm length of Teflon spaghetti tubing by the operative nurse (Figures 2A, B). The proper size mitral prosthesis is selected by visual inspection aided by the transparent valve obturator sizers. The prosthesis should be the largest size that fits into the anulus without the possibility of adjacent annular tissue interfering with movement of the toroid. The transparency of the valve obturator aids in this estimate. This valve is then placed in the valve holder (Figure 3). Each arm of the mattress sutures is placed about 8 mm apart through the mitral anulus, from above downward. The same sutures are then passed upward through the sewing ring of the valve and through the silastic suture holder disc on the midportion of the valve holder (Figures 3, 4). This disc is adjustable on the handle to meet varying operative conditions. Twelve to 16 sutures are used, depending upon the size of the mitral orifice.

*Teflon Spaghetti: Becton & Dickinson - Rutherford, New Jersey. Prop. No: 6438 Size: I.D. 0.038 O.D. 0.062 - 10 foot lengths/box

Teflon Spaghetti Cutter: made in The New York Hospital Apparatus Shop. Approximate cost $50.00
OPERATIVE TECHNIQUE (Continued)

After sliding the prosthesis into place in a slightly subvalvar position, the horizontal mattress sutures are tied, cut (Figure 5), and the valve holder removed. By leaving the valve holder in place while the stitches are being tied the valve is kept incompetent. In sliding the prosthesis down into the anulus, care should be taken to prevent undue redundancy of the stitches which might result in a stitch becoming snagged over one of the 4 struts on the valve cage. Even though the toroid valve holder holds the toroid firmly against these struts, it is still possible for a stitch to become snagged if some care in this regard is not exercised.

After all stitches have been tied, we visually inspect the valve and sometimes use a fine nerve hook to test free movement of the toroid before closing the left atrium.

When the left atriotomy is almost closed, both caval tapes are released to flush as much air as possible out of the pulmonary veins and left heart. Then the left atriotomy closure is completed while a thumbtack needle vent\(^7\) is inserted into the ascending aorta. Only then is the heart allowed to restart by removing the fibrillatory electrodes and defibrillating as necessary. No left ventricular vents are used or necessary with this technique.

At this date (12/1/69), slightly more than 200 toroidal valves have been inserted into the mitral (or tricuspid) area of patients.

At the Cornell Medical Center, anticoagulation with Coumadin is begun on the day the chest tube is removed (usually the second or third postoperative day) and has been continued indefinitely to date.

REFERENCES


LILLEHEI-NAKIB Heart Valve

OBTURATOR-SIZERS

MITRAL HOLDER WITH VALVE IN PLACE

AVAILABLE SIZES

MITRAL VALVES

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<th>ORIFICE DIAMETER</th>
<th>ORIFICE HYDRAULIC AREA (CM²)</th>
<th>VENTRICLE HEIGHT (MM)</th>
<th>WEIGHT (GMS)</th>
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OBTURATORS
(TRANSPARENT PLASTIC)

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MITRAL HOLDER
(Universal - All Sizes)

GRISMER-Lillehei
(Silastic Suture Needle Holder Attachment for Mitral Valve Holder) (See figures 3,4)