POST-OPERATIVE ECHODOPPLER ASSESSMENT
OF
BJORK-SHILEY VALVES AND THEIR EQUIVALENTS

THESIS

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FOR THE MASTER DEGREE IN
CARDIOLOGY

BY

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IL N'EST PAS CERTAIN QUE TOUT SOIT INCERTAIN

B. PASCAL (1623-1662)

بسم الله الرحمن الرحيم

INTRODUCTION AND AIM OF WORK

In the past 2 decades, several thousands of patients have undergone surgery for the replacement of their mitral and/or aortic valves in Egypt. This procedure has become increasingly vital and widespread in a country still burdened with a high rate of rheumatic valvular affection.

Of the various types of prostheses used for replacement of diseased native valves in this country, the commonest used is the tilting-disc mechanical valve, with its different makes, the Bjork-Shiley, Sorin, or other equivalent prostheses.

The proper follow-up of patients with prosthetic valves necessitates a deep understanding, by the physician, of the nature of these devices, of their functioning in vivo, as well as of their intrinsic limitations and the potential hazards that their eventual dysfunction may cause to the patient's safety and well-being.

So, it must be recognized that all valve replacements (mechanical prostheses as well as tissue valves) have an effective in-vitro orifice size that is smaller than a normal human valve (Ubago et al., 1980). After insertion, tissue ingrowth and endothelialization reduce the in-vivo effective orifice size further (Rahimtoola, 1978), and therefore most valve devices currently available must be considered to be at least mildly stenotic (Holen et al., 1978).

Also, despite improvement in the design and durability of prosthetic valves, malfunction still occurs (Sagar et al., 1986).

In the past 25 years since the first successful use of a prosthetic heart valve (Starr & Edwards, 1961), a sensitive and specific non-invasive tool for the accurate assessment of prosthetic valve function has been sought (Kotler et al., 1983). Fluoroscopy, M-Mode echocardiography, and echo-phonocardiography are helpful in assessing mechanical prostheses (Sands et al., 1982 - Verdel et al., 1983 - Douglas & Williams, 1974 - Brodie et al., 1976). None of these techniques, however, allows quantitative assessment of valve dysfunction that compares well to invasive evaluation (Williams & Labovitz, 1985) .

Several studies have been performed on the use of Doppler to palliate this deficiency , and the results suggest that Doppler echocardiography is a reliable method for the characterization of normal and abnormal prosthetic valve function (Sagar et al., 1986). Hemodynamic measurement by Doppler provide non-invasive information similar to that provided by cardiac catheterization that is reproducible and specific for valve dysfunction (Williams & Labovitz, 1985).

CHAPTER I

Artificial Heart valves

Historical review

The implantation of a caged-ball prosthesis in the descending aorta just distal to the left Subclavian artery as a treatment of aortic regurge by Hufnagel and his associates in September 1952 marked the beginning of the era of artificial heart valves (Hufnagel et al., 1954 - Fishbein et al., 1977).

- In 1958, Lillehei and Muller replaced the entire aortic valve with a prosthesis which is a bicuspid silicone rubber flap valve device and it was placed in the subcoronary position (Sabiston and Spencer, 1976).

These attempts at treatment of diseased native valves by the implantation of artificial ones were followed by others, as Harken and his associates reported in May 1960 on 5 cases of aortic valve replacement with caged-ball prosthesis (Harken et al., 1960 - Macmanus et al., 1980).

- In September 1960, the first successful implantation of a caged-ball prosthesis in the mitral position was achieved by Starr A (Starr & Edwards, 1961 - Carey, 1976).

- In 1962, Ross and Barratt-Boyes began the clinical application of aortic valve homograft replacement in the sub-coronary position (Ross, 1962 - Barratt-Boyes, 1964). This year also saw the publishing by Senning of his results in using autologus free-hand fascia lata as designed for aortic valve replacement (Sonnenblick and Lesch, 1974), and the innovation of Magovern and Cromie who devised their sutureless valve with an automatic fixation mechanism to allow rapid implantation (Magovern et al., 1977).

- In 1965, aortic porcine heterografts were first clinically used by Binet, Carpentier and their associates (Sang et al., 1979).

- In 1967, Ross utilised autologus pulmonary valves for aortic replacement, the patient's own pulmonary valves being, in turn, replaced with a reconstructed aortic homograft or aortic heterograft (Ross, 1967 - 1972).

- In january 1969, Bjork began the clinical use of the Bjork-Shiley central-flow monocuspid tilting disc valve in the mitral, then in the aortic position (Messmer et al., 1970 - Bjork and Olin, 1970).

- In february 1969, the Hancock porcine prothesis was first clinically implanted in the mitral position (Sang et al., 1979).

- In 1970, the Lillehei-Kaster disc valve was introduced

(Lefrak and Starr, 1979).

- In 1972, Nicoloff and Passas developped the St-Jude Medical valvular prosthesis. This device is a low profile bileaflet valve and it provides long durability, normal hemodynamics and antithrombogenicity (Halrlein et al., 1980). Zerbini used a homologous dura mater as a possible material for a construction of a new trileaflet prosthesis (Manothaya et al., 1980).

- In March 1976, the Ionescu-Shiley trileaflet pericardial xenograft was first implanted (Ionescu et al., 1977 - Williams et al., 1981) and proved to be a very promising tissue valve. This same year, the Carpentier-Edwards valve was released for general use (Stahmann, 1979).

Since then, numerous adjustments in the surgical techniques and in the designs of the protheses have continued to be made, in order to get as close as possible to the ideal heart valve substitute, which should be readily available, easily inserted, haemodynamically satisfactory, durable on the long term, and free from thromboembolic and infectious complications (Sang et al., 1979).

General Review of Valve Types

Artificial heart valves can be classified into mechanical prosthetic valves and tissue valves.

Mechanical prosthetic valves

These valves have an excellent record of durability. However, problems with thromboembolism persist despite the fact that the cloth covering of the sewing rings and struts has reduced the incidence of this complication considerably (Braunwald E., 1984).

In addition to this problem, there is the fact that all mechanical substitutes require long-term anticoagulant therapy. It is well known that, annually, approximately 1.4 to 3 per cent of patients on anticoagulants will have some minor or major haemorrhagic complications, for example, haematuria, gastrointestinal haemorrhage or intra-cerebral haemorrhage. Abrupt cessation of anticoagulant in patients with mechanical aortic valves undergoing unrelated surgical procedures may be accompanied by rebound coagulopathy (Macmanus et al., 1980).

Prosthetic valves are of either two types : the central occluder or the eccentric monocuspid valves.

* The central occluder may be of the caged-ball type (e.g. Starr-Edwards or the Smeloff-Cutter double-caged valve) or of the caged-disc type (e.g. Kay-Shiley) which were introduced to overcome the problems of poppet inertia and ventricular-prosthetic disproportion met with in ball valves use (Moussa, 1984 - Kay et al., 1966 - Beall et al., 1968 - Cross & Jones, 1966). Both types of valves (caged-ball and caged-disc) give eccentric flow, with blood passing circumferentially around their occluders.

A recently designed central occluder is the St. Jude bicuspid valve. This new prosthesis, in contrast to other central occluders, gives a central flow, and it has outstanding hemodynamics and a relatively low incidence of non-fatal emboli (Braunwald E., 1984). It is classified in the literature as either a central occluder or a central flow prosthetic valve.

* The eccentric monocuspid valves (e.g: Bjork-Shiley, Sorin or Lillehei-Kaster) were introduced in an attempt to reduce the postoperative pressure gradient associated with the central occluder prostheses, particularly in patients with narrow aortic roots. These new valves have a disc seated on a disc-stop, and tilting with angles between 50 and 80 degrees, depending on the type of valve and the position of its insertion, and providing a central flow. A wider opening angle

is thought to decrease stagnation below the pivot point of the valve and consequently lessen the incidence of thromboembolism (Moussa, 1984)

Tissue valves or Bioprosthetic valves

These valves were introduced mainly to overcome the complication of thromboembolism that appears to be inherent in the use of all mechanical prosthetic valves (Ionescu, 1979).

They are also life-saving when the patient presents an absolute or strong relative contraindication to the anticoagulation associated with the use of mechanical protheses, for example : woman in child-bearing period, blood diseases, peptic ulcer, etc..

The first of the tissue valves to be widely used were chemically sterilized homografts. Unfortunately, these exhibited a high incidence of breakdown and decay within 3 years (Ross, 1962). Fresh antibiotic-treated or frozen-irradiated homografts were then developped, which were somewhat more durable but proved to have a significant late failure rate due to collagen dissolution of the valve cusp (Barratt-Boyes et al., 1977), possibly representing a subtle form of rejection. Also, the procurement of homograft valves proved to be a formidable logistic problem (Braunwald, 1984).

Bioprostheses include homologous and heterogenous valves.

* Homologous valves include autografts from the patient's own tissues (e.g:dura mater,fascia lata), or allografts from human aortic or pulmonary valves.

* Heterogenous valves include the glutaraldehyde-fixed bovine pericardium or the porcine heterograft, both of which are utilized for fabrication of cardiac valves on valve struts (metal frames). These have been employed for quite a long time with good results of durability and low incidence of thromboembolism.' Porcine heterografts were developped and used clinically in 1965 (Braunwald E., 1988). They are composite tissue valves composed of porcine aortic leaflets mounted on flexible stents and pretreated with glutaraldehyde. This form of the Hancock porcine bioprosthetic cardiac valve was the first quality controlled, mass produced tissue valve and has been widely used in the mitral, tricuspid and aortic positions (Braunwald E., 1984).

Most of the prostheses (mechanical or biological) have been successfully used in the different cardiac valves positions. Of the tissue valves, only homografts are now restricted to the aortic position.

Table A names the commonest-used prosthetic valves worldwide, and table B summarizes their respective advantages and disadvantages.

Table A. COMMONLY USED PROSTHETIC VALVES

* MECHANICAL VALVES

I- Central Ball Occluder (Caged-ball):

1. Starr-Edwards.
2. Smeloff-Cutter.
3. Braunwald-Cutter.
4. Magovern-Cromie.
5. DeBakey-Surgitool.
6. Hufnagel.

II- Central Disc Occluder (Caged-disc):

1. Kay-Shiley.
2. Kay-Suzuki.
3. Beall-Surgitool.
4. Cooley-Bloodwell-Cutter.
5. Cross-Jones.

III- Eccentric Disc Occluder (Central-flow Tilting disc):

* Monocusp

1. Bjork-Shiley - Sorin.
2. Lillehei-Kaster.
3. Hall-Kaster.
4. Wada-Cutter.
5. Omniscience.

* Bicusp

St-Jude medical valve. (@)

* TISSUE VALVES or BIOPROSTHESES

1. Aortic valve homograft.
2. Hancock xenograft.
3. Carpentier-Edwards xenograft.
4. Ionescu-Shiley pericardial xenograft.
5. Dura mater homologous trileaflet valve.

(@) Sometimes classified under central occluders.

Modified after Mohsen O.. 1983 and Kotler et al., 1983.

TABLE B - ADVANTAGES AND DISADVANTAGES OF COMMONLY USED PROSTHESES

Type	Name-Model	Advantages	Disadvantages
ged ball (non–cloth-covered)	Starr-Edwards 1260, 6120 Smeloff-Cutter	1. Predictable performance 2. Abundant long-term experience 3. Inaudible	1. Thromboembolism 2. Anticoagulation 3. Bulky cage design
ged ball (Cloth-covered)	Starr-Edwards 2400, 6400	1. Very low incidence of thromboembolism	1. Anticoagulation 2. Bulky cage design 3. Noise 4. Hemolysis 5. Poor hemodynamics in small sizes
ing disk	Bjork-Shiley Lillehei-Kaster	1. Excellent hemodynamics 2. Very low profile 3. Durability	1. Anticoagulation 2. Thromboembolism 3. Noise
	St. Jude	1. Outstanding hemodynamics 2. Very low profile	1. Anticoagulation 2. Uncertainty about durability and actual incidence of thromboembolism
ine xenograft	Hancock Carpentier-Edwards	1. Very low incidence of thromboembolism 2. Central flow 3. No hemolysis 4. Inaudible 5. Anticoagulants usually unnecessary	1. Uncertain durability 2. Poor hemodynamic performance in small sizes (standard models)
ine pericardium	Ionescu-Shiley	1. Very low incidence of thromboembolism 2. Central flow 3. No hemolysis 4. Inaudible 5. Anticoagulants usually unnecessary 6 Excellent hemodynamics in aortic position	1. Uncertain durability 2. Gradients in mitral position

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