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Investigation of Bovine Aortic Valves in Cardiac Research for Bioprosthetic Purpose

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Abstract: An investigation was conducted to study the aortic valves of the heart of the indigenous cattle in cardiac research for bio-prosthetic purpose in Bangladesh. The measurement & observation of bovine heart & aortic valve in different age groups (1.5 years to 4.5 years old) are the findings of this research work. The results revealed that the size ranged from 21 to 35 mm and orifice diameter are similar in comparison with implanted aortic & mitral valves at National Institute of Cardiovascular Disease & Suhrawardee Hospital, Dhaka. It indicated that the selected bovine heart valve (specially aortic valves) were similar to human valve size & can be used in future for implantation as per as the size is concerned. On the other hand, the heart valves are devoid of blood supply as a result there is no problem with tissue rejection as it is in cornea transplant in the eye. The prospect is bright for further study regarding making these tissue valves implantation worthy for clinical use in the Cardiovascular Disease Hospital & private clinics in our country.

Key words: Aortic, valves, bovine, cardiac research and bioprostheses

Introduction

Cardiac diseases are the most common life-threatening problem of human beings, throughout the world irrespective of age, sex and races. Its prevalence varies from country to country and society to society depending on human habit. According to local and World Health Organization (WHO) report, it is considered to be the 2nd killer disease in Bangladesh.

Now a days, open heart surgery becomes an acceptable means of treatment of congenital, rheumatic and ischaemic heart disease at the National Institute of Cardiovascular Diseases (NICVD), Dhaka, Bangladesh. It has been estimated that about 50% of the resources and efforts of NICVD are used in the treatment of cases, which are mainly involved with the mitral and aortic valve replacement. At present, impaired/defective valves are replaced with mechanical or porcine tissue valves, which are imported and very costly. Although tissue valves of bovine origin have a good prospects for bioprostheses but some studies revealed that the heart valve size of indigenous cattle of Bangladesh has focused a very prospects similarity with human heart valve which has created the present thrust of research in this area.

A pilot study on heart valve size of indigenous cattle of Bangladesh has already been done by Khan & Islam (1991) that has focused a very prospective similarity with human heart valve which has created the present thrust of research in this area. On the other hand the products (cattle heart valve) of this research project will create a tremendous demand for the heart patient of Muslim population of the world due to the religious stigma.

There is no laboratory for the production of cardiac prosthetic or bioprosthetic materials in Bangladesh. These heart valves are devoid of blood supply & structurally consist of fibrous connective tissue, as a result there is no problem with tissue rejection as it is in cornea transplant in the eye. On the other hand, a new pericardial bioprosthetic heart valve has been designed and developed in the laboratory of the department of veterinary surgery, University of Glasgow by Spyt *et al.* (1988). The frame of the valve is covered with a single piece of chemically treated bovine pericardium. Due to the big size of high breed bovine heart, the whole bovine heart valves are not yet used anywhere for bioprosthetic purpose. The

measurement study of the size of bovine aortic heart valves in Bangladesh already has been done.

With mechanical heart valves and various animal tissues like pericardium, covering of the skull and latissimus dorsi muscle are being used in the preparation of bioprostheses and those have been reported by many authors. The heterograft aortic valves of pig heart for human was studied by Brien (1967). Carpentier *et al.* (1985) has also found it in valvular bioprostheses with whole porcine heart valves.

Therefore, the present research work was undertaken to study the anatomical structures of bovine heart valve with its implication towards bioprostheses.

Materials and Methods

The heart specimen of indigenous cattle (*Bos indicus*) were collected immediately upon slaughter at Gulshan slaughter house and Mohakhali residential area of Dhaka city of Bangladesh. The aortic roots were cut out from the heart. After rinsing away the blood they were put in balanced isotonic saline solution and stored in the refrigerator at 4°C (± 2 °C) until dissection was possible. The aortic roots were inspected for any damage of genetic defects prior to trimming. The genetic defects include thin leaflets, blood capillaries in leaflets, calcification and other degeneration defects. Only the acceptable aortic roots were trimmed and inspected again to avoid defective from being processed further. The three aortic sinuses of each valve were gently packed with cotton wool soaked in 10% formaldehyde solution. Actually 0.45% HEPES buffer glutaraldehyde solution has to be sole agent for both preservation and sterilization, but now for experimental purposes the valves were kept individually in plastic jars containing 10% formaldehyde solution. The orifice diameters of the collected aortic valves were measured by using valve sizers (made by Medical Inc. of the USA) and recorded. Mounting onto the flexible stents, fabrication suturing, quality control and appropriate preservation will be the final assembly for clinical use of these bioprostheses.

Results and Discussion

The proposed research project have been started from 1989 & still now it is being continuing at different places of Bangladesh like, NICVD, Bangladesh Agricultural University &

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Table 1: Study and observation of bovine heart and aortic valve in different age groups

Age(yrs.) of Animal	Genus and Species	No. of Animal Studied.	Av. Wt. Of the Animal (kg)	Av. Wt. Of the Heart (gm).	Av. size of the aortic valves orifice diameter (mm)
1.5	<i>Bos Indicus</i>	8	59.38	471.87	22.75
2.0	"	4	60.16	616.33	23.00
2.5	"	4	80.00	625.00	24.00
3.0	"	5	75.00	400.00	25.00
3.5	"	4	100.00	875.00	27.00
4.0	"	3	120.00	750.00	26.00
4.5	"	2	256.00	1000.00	35.00

Table 2: Prevalence of valve replacement in open-heart surgery cases at NICVD in (1989)

Types of Replacement	Total No. of Patient	Prevalence Rate	Size of the implanted Valve (mm)
Aortic Valve Replacement	27	22.13%	19-26
Mitral Valve Replacement	28	22.95%	27-33
Total	55	45.08%	19-33

Total number of open-heart surgery-122.

Table 3: Normal values of some physiological and hematological constituents in man and some other species of animals

Constituents and Units	Homosapiens (man)	Bovine (Cattle)	Caprine (Goat)	Ovine (Sheep)	Porcine (Pig)
Heart beat/min	70	67	80	80	75.0
Temperature °C	36.8	38.3	39.0	39.0	39.0
Respiration rate/min	18	20	25	25	15
No. of chromosomes	46	60	60	54	38
Blood volume % lives wt.	8.0	8.0	7.8	5.8	8.0
Reaction of blood (pH)	7.39	7.38	-	7.44	-
PCV %	47.0	30.5	34.0	35.0	39.0
RBC 10 ⁶ /cu. mm.	5.0	5.8	12.0	10.5	6.8
WBC 10 ³ /cu. mm.	1.5	6.9	7.0	8.0	16.0
HB(gm %)	16.0	10.9	10.6	11.5	10.4
Neutrophils %	65.0	29.3	39.0	26.0	33.0
Lymphocytes %	28.0	62.4	54.0	64.0	57.0
Monocytes %	28.0	62.4	54.0	64.0	57.0
Eosinophils	2.0	6.0	3.0	5.0	3.8
Basophils	0.5	0.3	0.5	0.5	0.2
Calcium meg/liter (s)	4.8	5.2	5.2	5.2	6.0
Cholesterol mg/100 ml	215	140	127	125	175
Chloride MEQ/liter (s)	105	80	112	102	102
Magnesium mg/100ml	-	2.5	3.0	3.0	3.0
Uric acid mg/100ml	5.0	1.1	0.7	1.1	1.1
Phosphate meg/L (s)	4.0	3.6	3.6	3.6	4.4
Creatinine mg/100ml	1.1	1.5	1.5	1.5	1.5
Glucose mg/100ml	85	53	53	40	100
Serum protein (T) mg/100ml	7.0	7.5	6.7	5.4	6.3
Albumin (s) gm/100ml	4.5	3.6	3.9	3.0	2.0
Globulin (s) gm/100ml	2.5	3.9	2.7	2.3	3.2
SGOT MM/ml at 37°C	25	49	17	110	30
Life span of RBC (day)	120	100	-	-	71

* Source: Duke's physiology of domestic animals, 9th ed. Copmstick was publishing associates Dhaka and London. by Swenson, (1977)

Sylhet Government Veterinary College. After an initial inspection of many types and sizes of the cattle of native breed (*Bos indicus*), a Selection was made from 1.5 to 4.5 years age group irrespective of sex as appropriate to the highest value of sizes ranging from 21 mm to 35 mm in diameter, which are normally used at NICVD Dhaka, Bangladesh. Results are shown in Table 1.

From the record of open heart surgery at NICVD it was observed that the sizes of the valve implanted is ranging from 19 to 33mm in aortic and mitral position (Table 2) and those were very similar to the sizes of the bovine aortic valves mentioned above (Table 1). Many physical and hematological constituents of indigenous cattle are closer to that of human in comparison with pig (porcine) (Table 3).

The Anatomical structures of the aortic valves of the indigenous cattle of Bangladesh are investigated in this research work. There are four kinds of valves named, Right artio-ventricular or Tricuspid valve, Pulmonary valve, Left artio-ventricular or Bicuspid valve and Aortic valve are present in the bovine heart and that has been observed in this study.

The main objectives of the present study are to investigate the morphology of the aortic heart valve. This valve has three cusps or leaflets, viz, Right, Left and coronary cusp. The right one is irregularly triangular in shape and in apposition with the artio-ventricular rings. The left cusp of the aortic valve is attached with the papillary muscle of the left ventricle by means of the chorditendineae. The fibrocartilaginous structure, the ossa cordis, is also found in the aortic fibrous ring. Mechanical aortic and mitral valves were first successfully implanted in human by Harken, (1960) and Starr & Edwards, (1961). Tissue valves, e.g., fresh Homograft (Allograft) aortic valves were first implanted in the subcoronary position in 1962 and proved virtually free of thromboembolic complications without anticoagulant therapy (Barraff Boyes and Roche, 1969). Since then much improvement and different design of prostheses and bioprostheses have been made (Carpentier, 1982).

At present, bioprostheses of Glutaraldehyde preserved & Flexible support-Mounted porcine valves are widely used (Carpentier & Edwards, 1985). Other tissue valves such as

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"Inoescu-shiley" for bovine pericardial xenograft (Inoescu, 1977). "Hancock" porcine xenograft and Angell-Shiley" valves are also used to some extent (Angelly *et al.*, 1979). Merits and demerits of different prostheses and structural changes of bioprostheses have been described by several cardiac surgeons and researchers (Bjork & Heinze, 1979 and Ashraf & Bloor, 1978). The bioprosthetic materials, such as cardiac valves are mostly of porcine (pig) origin, preserved in Glutaraldehyde, prone to calcification in long duration and are not suitable for use in children (Odel, 1982). Carpentier (1982) investigated the problems of calcification in implanted Glutaraldehyde preserved biological tissue. They found that biological tissue in association of formalin with glutaraldehyde reduced the calcification. Biological tissue incubated with amino acids such as alanine, cholamin, histidine and lysin also reduced the calcification (Carpentier, 1982). Jones, (1982) found that the changes in Bioprosthetic valves removed from human were similar to those in sheep. They concluded that the sheep model provided an excellent *in vivo* means for investigation of the preparation and design of bioprosthetic valves. The chemical composition of blood plasma in the mammals is similar to human being (Swenson 1977). The histological and histo-chemical structures of the heart valves of buffalo are similar to man structures, some physiological factors and hematological constituents of indigenous cattle are in close vaccinate to man in comparison with pig (Rahman *et al.*, 1984).

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