Histological Comparison of Bovine and Human Aortic Valves

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ABSTRACT

The clinical use of tissue valves of porcine natural aortic valve and bovine paricardial origin in valvular replacement in human emphasize knowing the histological similarities or dissimilarities of bovine heart valve with that of human. We compared the histological features of the aortic valve of bovine and human heart. A total of 10 heart specimens taking 5 aortic valves from the adult cattle’s of native breed (Bos indicus) and 5 aortic valves of adult human heart of both sexes were used in this experiment. The aortic valves of the collected bovine and human heart were harvested by dissection. The valves were fixed in 10% formalin and embedded with cotton plug just after harvesting and than the unwanted tissues of valves were trimmed out for histological studies. In the presented study, it was found that the cusps of the aortic valve of bovine and human heart composed of three main of tissue layers. From the aortic to the ventricular aspects, these layers were the fibrosa, the spongiosa and the ventricularis. The collagen bundles of the fibrosa were oriented parallel to the free edge of the cusps. The loose connective tissues were found in between the fibrosa and ventricularis. The ventricularis contained collagen fibres with enriched elastic fibers. Both the fibrosal and ventricular surface of the cusps of the aortic valve were lined by endothelium. The arrangement of the lining epithelium of the cusps was perpendicular to the blood flow of the left ventricular outflow tract of bovine and human heart. The blood vessels or capillaries were not found on the cusps of the aortic valve of both bovine and human heart. The thickness of the cusp of aortic valve of bovine heart was 193 µm and in the human heart was 145 µm. The findings of the present study indicated the similarities of bovine and human aortic valves.

Key words: Aortic valve, Bovine, Human, Histology

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INTRODUCTION

The histological comparison of bovine and human aortic valve is important to understand their histological similarities or dissimilarities in order to develop the bovine tissue valve for future bioprosthetic use in human cardiac patient. The microstructures of the aortic valve are essential for providing proper valve functioning. The biomechanical properties of the connective tissues of human aortic valve has been reported to be and these were composed of three principal layers, e.g., the fibrosa, the spongiosa, and the ventricularis, composed of collagen, elastin, and glycosaminoglycans (Broom, 1988, Schoen, 1989, Freant, 2002). The aortic valve leaflet consisted of three distinct connective tissue layers covered by the endothelium on both the aortic and the ventricular side of the leaflet (Deck, 1986). In this regard, Schoen (1989) observed that the endothelial cells lined the surfaces of the valves and the fibroblasts were predominant in the deep layer of the valve.

Regarding the similarities of the aortic valve microstructures among animals and human, Prasad and Sinha (1984) reported that histological and histochemical structures of the cardiac valves of buffalo have the similarities with the valve structures of the other species of domestic animals and human being. However, the histological comparison of aortic valve between indigenous breed of bovine and human is lacking. Therefore, the present study was undertaken to study the histological comparison of bovine and human aortic valve.

MATERIALS AND METHODS

Collection of heart specimens

A total of 10 (ten) aortic valve specimens five from indigenous bovine and five from human heart were used in this study. The bovine heart specimens were collected from the slaughter house immediately after slaughtering with aseptic measures. The human heart specimens were collected from the cadaver immediately after postmortem with the permission of the head, department of forensic medicine, Mymensingh Medical College, Bangladesh. The specimens were put in a polythene bag containing ice and carried in a thermo flask to the laboratory. After rinsing away the blood, the specimens were kept in the balanced isotonic saline solution until dissection.

Harvesting of aortic valves

The collected heart samples were dissected following standard surgical procedure, the aortic valves were harvested and kept in the fixatives for histological processing.
Fixation and trimming of valves

The harvested aortic valves of the indigenous cattle and human heart were fixed in 10% formalin and embedded with cotton plug just after harvesting to retain the normal shape of the aortic cusps. The unwanted tissues of valves were trimmed out for further histological studies. The tissues from of the cusps of the aortic valves were selected for histological studies (Islam et al., 2002).

Preparation of selected tissues of bovine and human for histological studies

The selected tissue samples were cut into small pieces and the specimens were immediately fixed in 10% formalin solution (Gridley, 1960) for 24 hours. The tissues were then dehydrated in ascending graded alcohol (70%, 80%, 90%, 95% and absolutes), cleared in xylene and infiltrated in soft, medium and hard paraffin. Then the tissues were embedded in hard paraffin. Finally the paraffin sections were cut at 6μ thicknesses using sliding microtome (MIC 509, Euromex Japan). After cutting, the sections were floated on warm water in a water bath at 45°C for stretching, and then mounted on glass slides smeared with egg albumin and dried in slide warmer at 37°C for 24 hours. After drying, the sections were stained with standard Hematoxylin and Eosin (H & E) method for general histological study (Gridley, 1960).

Thickness of the cusps of aortic valves

The ocular micrometer and objective micrometer were used in the present study to measure the thickness of the cusps of the aortic valves. The thickness of the selected bovine aortic cusps were measured by a calibrated eyepiece micrometer scale (FUJI, KAKI) and compared with the thickness of the cusps of human aortic valve.

Microphotography of stained micro-slides of valve tissues

The microphotographs were made from the stained micro-slides using Olympus photomicrograph (Model No. CHS, Japan) at the Department of Pathology and these were showed in this manuscript for the illustration of histological comparison of the bovine and human aortic valve.

RESULTS

In the present study, it was found that the cusps of the aortic valve of bovine and aortic human heart composed of three layers viz. fibrosa, ventricularis and spongiosa. The fibrosa of the cusp of the aortic valve composed of distinct collagen fibers and arranged in a woven form pattern in the present study. These collagen fibers were also
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arranged as corrugated in this layer of the cusps. The spongiosa, consisting of loose connective tissues were found in between the fibrosa and ventricularis. In the ventricularis, the prominent elastic fibers are enriched and aligned in a radical direction, perpendicular to the free margin of the cusps of aortic valve of bovine and human heart (Figures 1A and 1B).

In the present study, the fibrosal and ventricular surface of the cusps of the aortic valve of the bovine and human heart were lined by endothelium (Figures 1A and 1B). The arrangement of the lining epithelium of the cusps was perpendicular to the blood flow of the left ventricular outflow tract of both the bovine and human heart. The fibroblast composed of flattened nuclei, which were found in the section of the cusps (Figures 1A and 1B). In the present study, the thickness of the cusp of aortic valve of bovine heart was 195 micron and in the human heart was 145 micron.

DISCUSSION

In the present study, histology of the aortic valve of the bovine and human heart was observed. It was found that, the fibrosa of the cusp of the aortic valve was composed of distinct collagen fibers, the spongiosa was consisting of loose connective tissues, and the ventricularis was composed of elastic fibers. Freant (2002) found that the fibrosa was composed of dense collagenous fibrous tissue subjacent to the endothelium of the aortic surface. He noted that the ventricularis consisted of elastic tissue subjacent to the endothelium, and the spongiosa, a thin layer of loose mesenchymal tissue between the fibrosa and ventricularis contains glycosaminoglycans, which was responsible for water and ion transfer and supports the fibrosa (Schoen, 1989). Broom (1988) reported that the ventricularis of each aortic valve cusps contained elastin-rich fibers aligned in a radial direction, perpendicular to the leaflet free margin and collagen component lying parallel to the free margin in a circumferential direction. The aortic side, which was referred to as fibrosa contained a collagen-rich layer. These fibers were also arranged in a circumferential direction as observed in bovine. The spongiosa consisted mainly of loose connective tissue or mucopolysaccharides. He also added that these principal layers of the aortic leaflet provide the necessary biomechanical properties for proper valve function. Similar histological structures were investigated in human heart (Schoen, 1989, Todd et al., 1998). Todd et al. (1998) also reported that these findings have broad implications for understanding structure-function relationships of these tissues.

In the present study, endothelial cells lined both the fibrosal and ventricular surface of the cusps of the aortic valve of bovine and human heart. Freant (2002) reported that the endothelium was the most superficial covering of the valve that covers both sides of each valve leaflet of aortic valve in human heart. Deck (1986) found that endothelial cells
Figure 1A,B. A is microphotograph of a section of the aortic cusp of bovine heart showing the fibrosa (F) containing collagen bundles (CB) and collagen fibers (CF) parallel to the free margin of the cusp, spongiosa (Sp) composed of loose connective tissue (arrow heads) and elastic fibers (EF) perpendicular to the free margin of the cusp are present in the ventricularis (V). The surface of the cusp is lined by endothelium (E) and the fibroblasts composed of flattened nuclei were also found in the section of the cusp (arrows). H & E × 600. B is a microphotograph of a section of the aortic cusp of human heart showing the fibrosa (F) containing collagen bundles (CB) and collagen fibers (CF) parallel to the free margin of the cusp, spongiosa (Sp) composed of loose connective tissue (arrow heads) and ventricularis (V). The surface of the cusp is lined by endothelium (E) and the fibroblasts composed of flattened nuclei were also found in the section of the cusp (arrows). H & E × 600

on the aortic valve leaflet of human heart were arranged in a circumferential pattern. The arrangement of endothelium on the surface of the cusp of aortic valve of bovine
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heart has similarities with that of human heart. The blood vessels or capillaries were not found in the aortic cusps of bovine and human heart. Weind et al. (2000) reported that normal valves were known to be metabolically active, although, the route of oxygen delivery was unclear. Although diffusion from the valve surface was the presumed source, the distribution and importance of the aortic valve’s vascular bed was unclear. They concluded that the metabolic activity of the cusps could be supported by diffusion from the cusp surface alone. The variation in the thickness of the cusps in bovine and human heart in the present study was due to species variation.

REFERENCES


