Global Veterinaria 4 (4): 374-379, 2010
ISSN 1992-6197

Macroscopic and Microscopic Studies on Moderator Bands in the Heart of Ostrich (*Stuthio camelus*)

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Abstract: The wall of the ventricle bears septomarginal trabeculae (moderator band) which extend from the interventricular septum to the opposite wall. These are partly muscular and partly tendinous and vary in different subjects. For study of the moderator band, 12 hearts of the ostrich were collected and the right and left ventricles of each heart were opened. This study revealed that moderator bands found in both right and left ventricles in the ostrich heart in different location. Two types of these bands were encountered: fibrous and fibromuscular. The right ventricle presents one fibro-muscular moderator band about the base of ventricle and small multiple strands as network near the apical region of ventricle. In the left ventricle some present between trabeculae carneae and some extend from interventricular septum to parietal wall. For histological study, specimens of moderator bands from both ventricles were separated. Routine paraffin sectioning with special staining and transmission electron microscopy method were performed. Histological examination showed that fibro-muscular band is composed of cardiac muscle in different ratio, blood vessels, connective tissue and purkinje cells. A fibrous moderator band was like fibro-muscular, but lacks cardiac muscle. These bands are suggested to be radiation of the His bundle. Purkinje cell was pale oval cells which have little myofibrils, cellular organelles and glycogen. They had intercellular junction with each other.

Key words: Moderator band · Heart · Ostrich · Anatomy · Histology · Ultrastructure

INTRODUCTION

The moderator band (Septomarginal trabeculae) is a single or branched muscular- tendinous strand that extends across the lumen of right ventricle and connects the interventricular septum to the ventricular free wall. The extremity of the trabeculae usually branches repeatedly as it blends with the muscular ridge of outer wall of right ventricle [1]. The function of this structure is to prevent over dilatation of the right ventricle during diastole and to allow purkinje`s fibers to extend from the atrioventricular bundle branch to the papillary muscles and myocardium of right ventricular parietal wall [2].

The right ventricular moderator band was described in human and some mammals [3]. Moderator band crossing the cavity of the left ventricle was first reported in 1893 by Turner [4]. In 1906, Keith and Flack noted that they were almost present in both bovine and human hearts and they regarded them as being part of the left bundle branch distributing of the purkinje conduction fibers [5]. The left ventricular moderator band in the heart of human [6,7], horse [2], dog [8] and cat [9,10] was occasionally seen, but not always.

The structure of the moderator band in the avian hearts has not been clearly defined and no description has been given in literature. Therefore, this report described the anatomy and histology of right and left moderator bands, as well as the fine structure of their purkinje fibers in the ostrich heart.

MATERIALS AND METHODS

A total number of 12 healthy adult ostrich hearts was obtained from slaughterhouse. Each heart was washed with normal saline and the ventricles were opened near the interventricular septum in each side. Blood clots, if present, were washed out from ventricles. Then each heart submerged in buffer formalin 10% for 72 hours. After complete fixation, the location and macroscopic structure of right and left moderator bands have investigated.

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For histological study, the moderator bands were separated from ventricles. For light microscopic study, the fixed samples were processed and they were sectioned 6 µm. Then the sections were stained by using Hematoxylin-Eosin, Masson's Trichrome, Orcein-Van Gisson and AZAN and were mounted.

For transmission electron microscopy, the specimen was fixed in 2.5% gluteraldehyde, washed in 0.1% phosphate buffer, post fixed in 1% osmium tetroxide. Then they dehydrated through a graded ethanol series and epoxy propane and embedded in TAAB resin. The ultrathin sections were cut in transverse and longitudinal plane of the bands and stained with uranyl acetate and lead citrate. After observing under transmission electron microscopy (Philips CM10), the electronmicrograph were prepared.

RESULTS

The macroscopic and microscopic studies revealed that, the moderator bands are found in different position in the right and left ventricles in the ostrich heart. There was a variation in their shape, number and histological characteristics.

In the right ventricle, there is one musculo-tendinous moderator band about the base of the ventricle, which extends from the interventricular septum to the muscular stalk of the muscular valve. It was single and sometimes branched. Histologically, these moderator bands have two structural forms and can be divided into initial and distal part. The initial part consists of stands of cardiac muscle fibers, which contain arterioles centrally located and these fibers are surrounded by large purkinje cells and endocardium. The distal part of one form of these moderator bands consists of only dense irregular connective tissue and in the other form the purkinje cells fill the core of moderator bands. There was cell-to-cell communication between purkinje fibers within the bundle. The purkinje cells were surrounded by connective tissue sheath (Fig. 1).

The sheath-like moderator bands present in right ventricle and extend between interventricular septum and parietal wall. They are consist of longitudinal muscle fibers in central with purkinje cells in peripheral and are covered by endocardium. In some area, the myocardium and purkinje cells are mixed (Fig. 2).

The thick moderator bands in the apex of right ventricle have 3 parts. The core of initial part fill with myocardium and they surrounded by small purkinje cells.

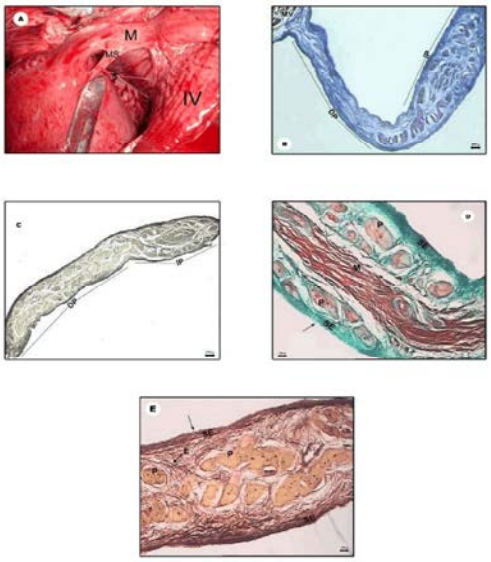

Fig. 1: Musculo-tendinous moderator band in the apex of right ventricle in the male ostrich heart. A) Location of a moderator band (*) which extend between the interventricular septum (IV) and muscular stalk (MS) of right muscular atrioventricular valve (M). B) Photomicrograph of one form of moderator band in A. Initial part (IP), distal part (DP), AZAN stain (×50). C) Photomicrograph of the other form of moderator band in A. Initial part (IP), distal part (DP), Orcein-Van Gisson`s stain (×32). D) Photomicrograph of the initial part. Purkinje fiber (P), cardiac muscle (M), subeddothelial layer (SE), endothelium (arrow), Masson`s Trichrome stain (×72). E) Photomicrograph of the distal part in fig.c. Purkinje fiber (P), subendothelial layer (SE), elastic fibers (E), endothelium (arrow). Orcein- Van Gisson`s stain (×72).

In the middle part, only the purkinje cells present in the loose connective tissue. The distal part of these bands is thin and consists of dense irregular connective tissue with a few clumps of purkinje cells (Fig. 3).

Fibrous-thread like moderator bands at the junction of the interventricular septum with the free wall of right ventricle was made apical networks. They were tendinous cords or partly muscular and partly tendinous. Histologically these are consisted of central purkinje fibers and peripheral dense connective tissue which covered by endothelium. The muscular part was characterized by the presence of a thin endocardium peripherally and myocardium centrally (Fig. 4).

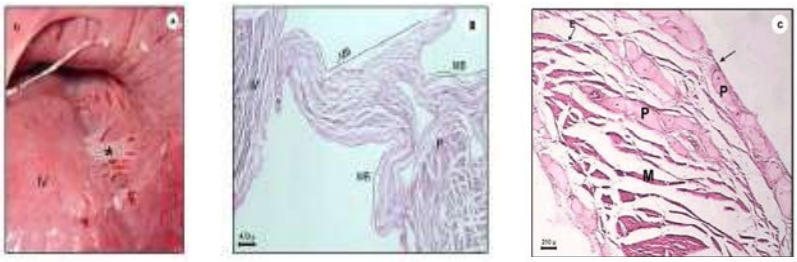

Fig. 2: Sheath-like moderator band in the right ventricle in the ostrich heart. A) Interior feature of right ventricle. Moderator band (*), muscular valve (M), interventricular septum (IV). B) Photomicrograph of moderator band (MB), interventricular septum (IV), parietal wall (P), H-E stain (×32). C) Purkinje fiber (P) and cardiac muscle (M) are mixed. Elastic fiber (E), endothelium (arrow). H-E stain (×72)

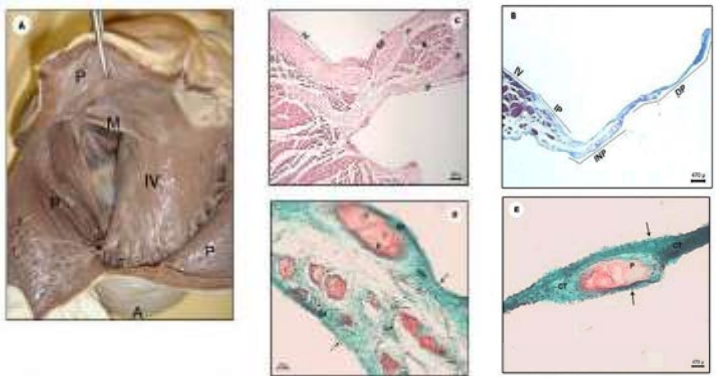

Fig. 3: Thick moderator bands in the apex of right ventricle in the male ostrich heart. A) Showing location of the thick moderator bands (*). Apex (A), muscular valve (M), interventricular septum (IV), parietal wall (P), trabeculae carneae (T). B) Photomicrograph of thick moderator band. Initial part (IP), intermediate part (INP), distal part (DP), interventricular septum (IV). AZAN stains (×32). C) The initial part (IP), cardiac muscle (M), purkinje fiber (P), subendothelial layer (SE), endothelium (arrow). H-E stain (×45). D) The intermediate part, purkinje fiber (P), connective tissue (CT), subendothelial layer (SE), endothelium (arrow). Masson`s Trichrome stain (×180). E) Distal part, purkinje fiber (P), connective tissue (CT), endothelium (arrow). Masson`s Trichrome (×180).

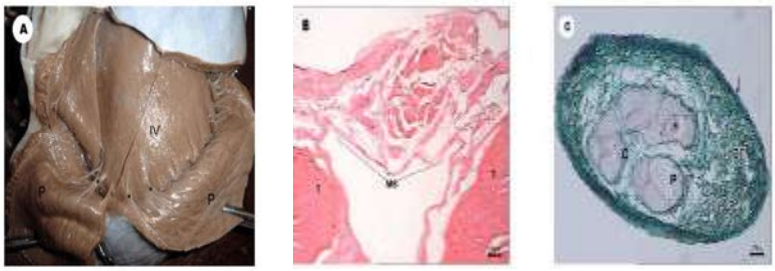

Fig. 4: Fibrous threat-like moderator bands make network in the apex of right ventricle in the male ostrich heart. A) The apex of right ventricle, moderator band (*), interventricular septum (IV), parietal wall (P). B) Photomicrograph of muscular part of moderator band (MB) between trabeculae carneae (T). H-E stain (×72). C) Cross section of fibrous part. Purkinje fiber (P), connective tissue (CT), capsul (C), endothelium (arrow). Masson`s Trichrome (×180).

In the left ventricle, there were tendinous moderator bands close to the apex. Some of them extend from the interventricular septum to the parietal wall in the form of irregular branch that anastomose each other and the others as thin thread-like bands extend between trabeculae carneae of the parietal wall. Microscopically,

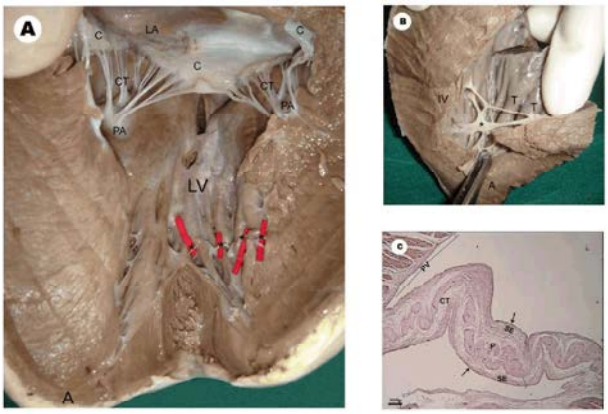

Fig. 5: Fibrous moderator bands in the left ventricle in the male ostrich heart. A) Moderator band (*) extend between trabeculae carneae in the left ventricle (LV), apex (A), papillary muscle (PA), chordate tendineae (CT), cusps of left atrioventricular valve (C), left atrium (LA). B) Irregular branches of moderator bands (*), interventricular septum (IV), apex (A), trabeculae carneae (T). C) Photomicrograph of fibrous moderator bands. Purkinje fiber (P), parietal wall (PV), connective tissue (CT), subendothelial layer (SE), endothelium (arrow). H-E stain (×45).

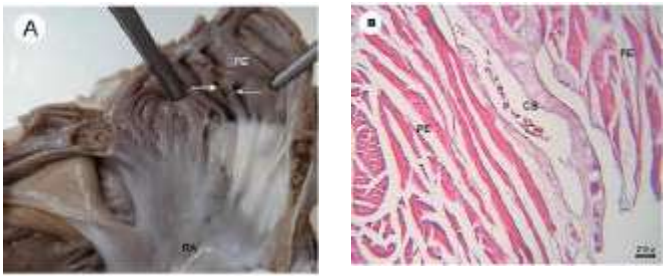

Fig. 6: Fibrous connecting bands between pectinate muscles in the right atrium. A) Location of fibrous bands (arrow) between pctinate muscle (PE) in the right atrium (RA), white fibrous sheet (WP). B) Photomicrograph of these connecting bands (CB) between pectinate muscles (PE). H-E stain (×72).

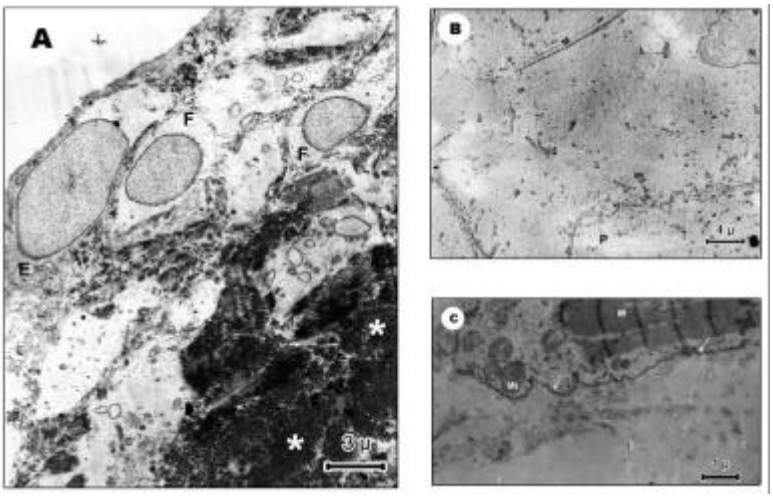

Fig. 7: Electromicrograph of moderator bands. A) The endothelium (E) and subendothelial layer of moderator band. Fibroblast (F), collagen fibrils (*). Uranyle acetate and lead citrate stain (×8190). B) the cluster of purkinje cells in the moderator band. Mitochondria (Mt), leptomeric organell (L), myofibrils (M), nucleus (N), desmosomes (arrow). Uranyle acetate and lead citrate stain (×3465). C) The muscular part of moderator bands. Myofibrils (M), mithochondria (MT), hemidesmosomes (arrow). Uranyle acetate and lead citrate stain (13881).

these were composed of purkinje fibers surrounded by loose or relatively dense connective tissue, covered externally by a single layer of endothelial cells. There is a sheath of fibrous tissue around the purkinje cells in the moderator bands (Fig. 5).

In the right atrium, between pectinate muscles, some fibrous bands like moderator bands were seen. Histologically, their structures were like fibrous moderator bands, composed of purkinje fibers surrounded with dense connective tissue and covered by endocardium (Fig. 6).

With the electron microscopy, the endocardium of moderator bands consists of endothelial lining and a sub-endothelial layer of dense connective tissue with collagen, elastic fibers and fibroblasts. Purkinje cells are very easy to distinguish. They are pale, round or oval cells, which have an empty appearing cytoplasm due to the small number of myofibril and a few randomly distributed organelles, mainly mitochondria. Their glycogen content is very little. They have one or two nuclei with no perinuclear clear area. They have a poor affinity for the EM stains, just as for toluidine blue. The distribution of these cells in the moderator bands may be either isolated or clustered and their intercellular junctions are simple with only a few desmosome and facia adherence (Fig. 7).

DISCUSSION

The septomarginal trabeculae (moderator band and also termed as false tendons) tend to prevent overdistention of the heart during systole and serves as the medium for passing purkinje fibers across the lumen of the ventricle, forming a part of the conducting system [1].

In the ostrich heart, there were moderator bands in both, right and left ventricle. The right ventricular moderator band are significant in normal animals and usually in the left ventricle of human [6], equine [2], feline [9, 10] and canine [11] hearts, but the other domestic animals show theses bands only in the right ventricle.

Anatomically, the location of the moderator band in the right and left ventricle of the ostrich heart is different from the other animals. There were no papillary muscle in the right ventricle of the ostrich and the moderator band attach directly to the ventral surface of muscular valve from interventricular septum. Since in human [12,13] the moderator band extends between interventricular septum and ventricular free wall and in domestic animals [2] and ungulate [14] these bands extend from interventricular septum to the papillary muscle and there is no connection to the vulvar cusps. In the ostrich left ventricle, despite the presence of papillary muscle, these bands have no connection to them.

Histologic structure of moderator band showed that they have muscular tissue in various proportions with connective and conductive tissue. It is similar to that of the human [7], ungulate [14], sheep [13, 15] and goat [13] hearts but in the carnivours, a real moderator band was never found [14]. Whatever is the size and shape, the moderator band must be regarded as the shortest pathway from interventricular septum to the free wall of left and right ventricle in the ostrich and the other animals.

The purkinje fibers are large in size and similar in most cellular characteristics in ostrich and dog [11], but in the ostrich, there is no peri-nuclear clear area. There is a little glycogen in these cells, but in human and mammals these cells are rich in glycogen [3, 16]. The purkinje fibers are organized into the bundle with cell-to-cell communication and little lateral communication. In the ostrich, there is a sheath of connective tissue around the purkinje cells, but in human and mammals there is no fibrous sheath around these cells [2]. This organization of the bundle fibers increase the spread of propagated impulses and inhibits the transverse spread.

ACKNOWLEDGEMENTS

We are grateful to the research council of the Shiraz University for providing financial assistance. Special thanks are also given to Mr. Moghisi and Mr. Safavi for their technical assistance.

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