

# Morphology of the Heart of a White-cheeked Gibbon (*Hylobates concolor*)

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## Abstract

The heart was recovered at post mortem from an adult white-cheeked gibbon, *Hylobates concolor*, for anatomical and histological studies. Macroscopically, it had oval shape, blunt and spherical apex with 3.5 cm. and 5 cm. in width and length. Smooth edged comma-shaped right auricle was markedly bigger than the jagged-edged left auricle. Pectinate muscles were found both at the internal surface of the right auricle and lateral free wall of the right atrium, while limited only in blind part of the left auricle. The coronary arteries supply was left coronary type. The left coronary artery gave circumflex and paraconal interventricular branches. Subsinuosal interventricular and intermediate branches ramified from the circumflex branch. One septal and two papillary muscles were found in both left and right ventricles. There was only one small trabecula septomarginalis in the left ventricle, but three in the right ventricle. Aortic arch gave off brachiocephalic trunk and left subclavian artery. Ligamentum arteriosum linked between the beginning of descending aorta and the junction between the left pulmonary artery and the pulmonary trunk. Histological results were generally indistinct. However, number of blood vessels observed in the atria was less than in the ventricles. Collagen fibers were the major fiber population of the subendocardium while elastic fibers were confined mainly in the subendothelial layer.

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**Keywords :** white-cheeked gibbon, heart, anatomy, histology

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## บทคัดย่อ

### สัณฐานวิทยาของหัวใจชะนีแก้มขาว

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ในการศึกษาหัวใจของชะนีแก้มขาว พบว่ามีลักษณะกลมรี รูปไข่ ปลายมน กว้าง 3.5 ซม. ยาว 5 ซม. แบ่งเป็น 4 ห้อง auricle ข้างซ้ายมีผิวนอกไม่เรียบ ขอบหยัก ขนาดใหญ่และกว้างกว่าข้างขวา ซึ่งมีลักษณะเป็นรูปจุดภาค ขอบมน ปลายเล็กแหลม ภายในหัวใจห้องบนขวา พบ pectinate muscles ทั้งด้านในของ auricle และผนังด้านข้างของ atrium ส่วนในห้องซ้ายพบเฉพาะใน auricle เท่านั้น ระบบเลือดที่มาเลี้ยงหัวใจเป็นแบบ left coronary type เส้นเลือด left coronary artery แยกให้ 2 แขนง คือ circumflex branch และ paraconal interventricular branch ส่วน subsinuosal interventricular และ intermediate branches แยกออกมาจาก circumflex branch ทั้ง ventricle ข้างซ้ายและขวา พบ papillary muscles ข้างละ 3 อัน โดยพบที่ผนังกลาง 1 อันและที่ผนังอิสระ 2 อัน พบ trabecula septomarginalis ขนาดเล็ก 1 อันที่ห้องล่างซ้าย และพบ 3 อันที่ห้องล่างขวา aortic arch แตกแขนงให้ brachiocephalic trunk และ left subclavian artery พบ ligamentum arteriosum เชื่อมระหว่างส่วนต้นของ descending aorta และรอยต่อระหว่าง left pulmonary artery และ pulmonary trunk ลักษณะทางจุลกายวิภาคโดยทั่วไป ไม่มีความแตกต่างอย่างเด่นชัด แต่พบว่าเส้นเลือดที่พบในหัวใจห้องบนมีจำนวนน้อยกว่าที่พบในห้องล่าง ชั้น subendothelial layer พบเส้นใย elastic เป็นส่วนใหญ่ ส่วนชั้น subendocardium ซึ่งมีความหนาแน่นมากกว่า พบเส้นใย collagen fibers เป็นจำนวนมาก

คำสำคัญ: ชะนีแก้มขาว หัวใจ กายวิภาค จุลกายวิภาค

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## Introduction

White-cheeked gibbon (*Hylobates concolor leucogenys* or *Hylobates concolor*), also called black gibbon or crested gibbon, is generally classified as the small tailless man-like ape (anthropoid) like chimpanzee, gorilla and orangutan (Janson and Joyce, 1996; Macdonald, 1999). The animal habituates in the rainforests of South and Southeastern Asia such as Thailand, northern Laos, northwestern Vietnam, Cambodia and Southeastern China (Macdonald, 1999; Geissmann et al., 2000; Zoothailand, 2007). However, only little is known about the heart of the animals in this family, we hope our report could provide the basic anatomical and histological data of the heart of white-cheeked gibbon and be beneficial for further researches.

## Materials and Methods

Adult male white-cheeked gibbon weighing 5.5 kg from Dusit zoo, died with non-cardiovascular cause,

were sent to perform the postmortem autopsy at the pathology unit, Department of Pathology, Faculty of Veterinary Science, Chulalongkorn University. Heart was removed from the thorax and kept in 10% formalin, then was carefully dissected. The size, shape, weight, width and length were identified, described, sketched and measured at macroscopic level. Tissues from both atria and ventricles were sampled as small pieces, immersed in the same fixative for 2 days at the room temperature, then were dehydrated and process routinely for paraffin embedding and cut into section at 5-7  $\mu$ m thick. The sections were stained with H&E and Masson's trichrome, then observed under light microscope.

## Results and Discussion

### Macroscopic finding

The heart of the white-cheeked gibbon has oval shape with a blunt, spherical apex like in the dog (Evans and Christensen, 1979). Its longest cranio-caudal

and basio-apex axis was 3.5 cm and 5 cm, respectively. Apparently, coronary, intermediate, subsinuosal and paraconal interventricular grooves are similar to those in ruminant and pig (Ghoshal, 1975<sup>c,d</sup>). The amount of yellowish subepicardial fat in the coronary groove is more abundant than in the interventricular groove.

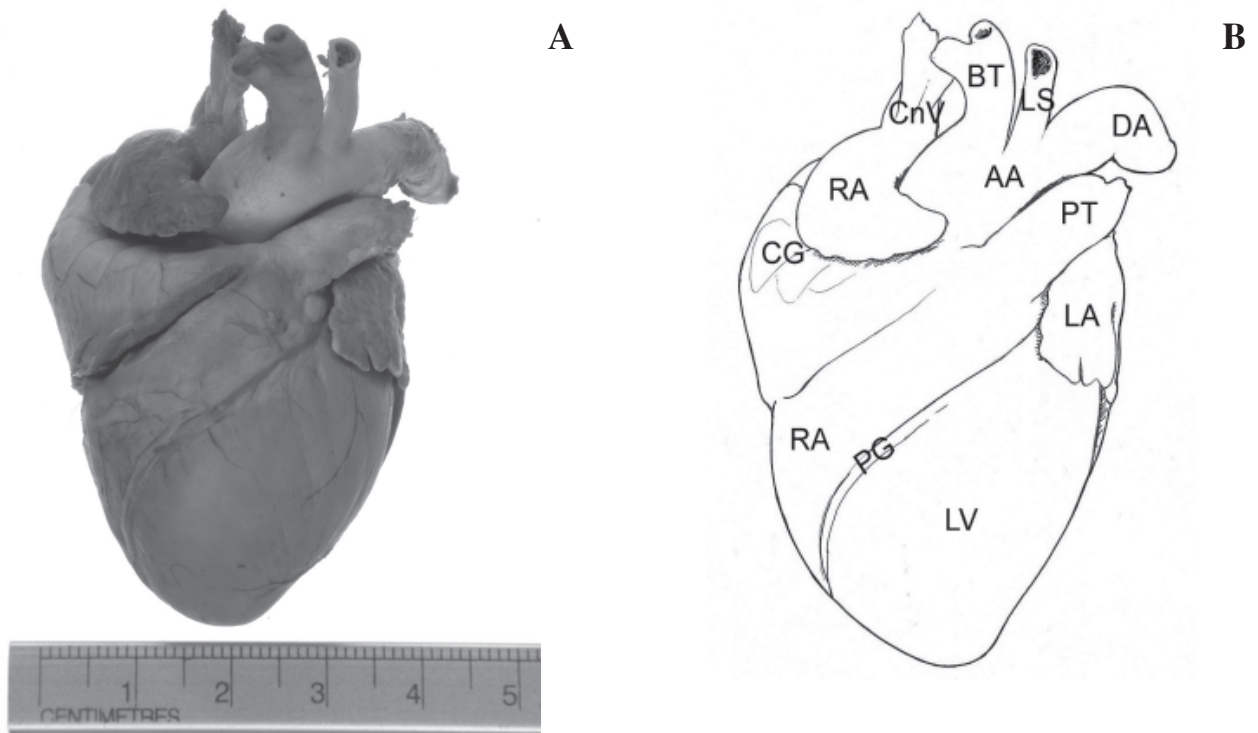
Both auricles were apparently seen in auricular surface (Fig. 1). Right auricle was in the form of comma shape with rather smooth edge, whereas the left auricular edge was jagged. The concave border was corresponding with the ascending aorta, while the convex border lied closed to the conus arteriosus. Left auricle was rather larger than the right one and slightly covered the beginning of paraconal interventricular groove like anterior interventricular groove in human (Agur and Lee, 1999). Left coronary artery emanated from ascending aorta and then bifurcated into circumflex and paraconal interventricular branches. The circumflex branch coursed within the coronary (atrioventricular) groove and terminated as subsinuosal interventricular branch in its corresponding groove on the right side. The paraconal interventricular branch descended in the paraconal interventricular groove without reaching the apex, then anastomosed with subsinuosal interventricular branch which similar to that in ruminant and pig (Nickel et al., 1981). In addition, the intermediate branch rose from circumflex branch, extended ventrally into the intermediate groove on the left side but terminated before reaching the apex (Figs. 2, 3). Internal diameter of ascending aorta, aortic arch and descending aorta was about 0.9 cm. The aortic arch gave rise brachiocephalic trunk and left subclavian artery which was similar to that found in dog, pig and guinea pig (Nickel et al., 1981; Kabak and Haziroglu, 2003) with an internal diameter of 0.4 cm and 0.3 cm, respectively (Figs. 1, 3). While gave 3 branches in the majority of human (Gupta and Sodhi, 2005) and only 1 branch; brachiocephalic trunk, in horse and ruminant (Ghoshal, 1975<sup>b,d</sup>).

Left interatrial septum had smooth surface while the auricular free wall was rough with the interlacing

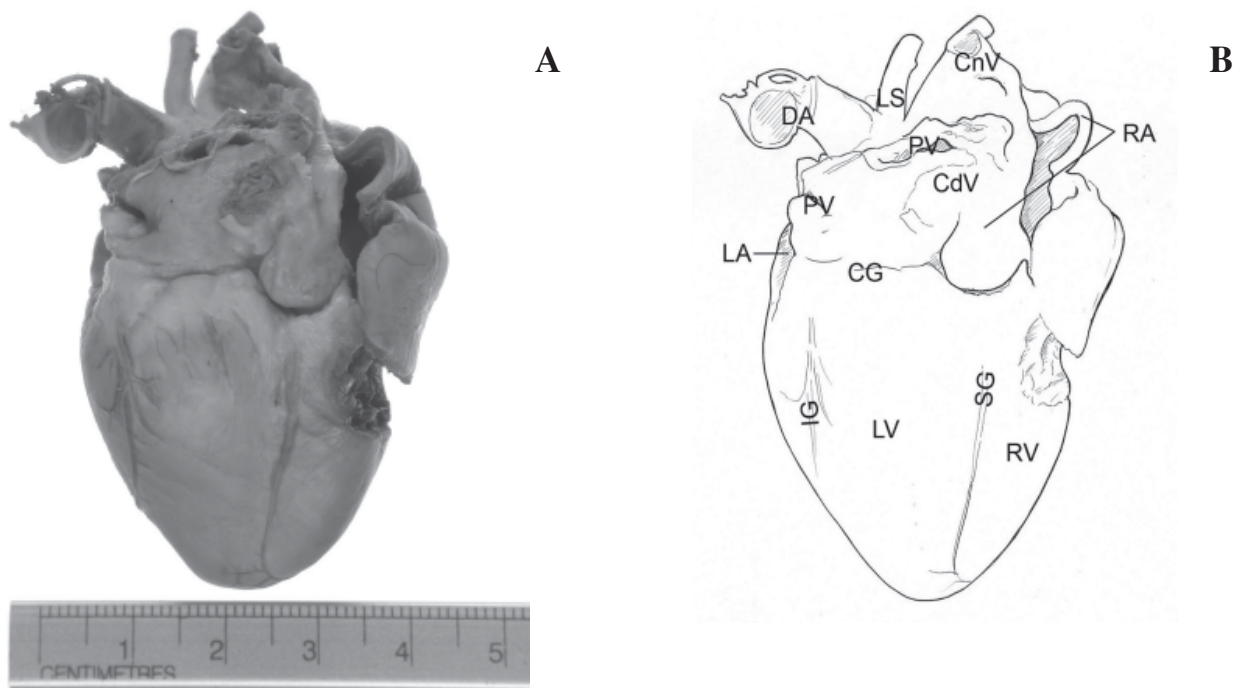
pectinate muscles. The prominent terminal crest was found at the junction of auricle and atrium. Three pulmonary veins entered the left atrium. Three compact papillary muscles were found in the left ventricle. One septal papillary muscle of 0.5 cm in width and 0.8 cm in length was identified at the interventricular wall. The other two parietal papillary muscles of 0.2 cm in width, 0.6 and 0.7 cm in length, respectively, were found at the ventricular free wall. All muscles gave rise to groups of chordae tendineae, which radiated to anchor to the free border and the luminal surface of left atrioventricular (tricuspid) valves (Figs. 4, 5). Only one small trabecula septomarginalis of 0.03 cm in diameter and 0.6 cm in length was found at the bottom of the ventricle.

Interestingly, pectinate muscles were identified both in the right auricle and also at lateral free wall of the right atrium which was unlike in the left side (Figs. 4, 5). This finding would reflect to its contractile activity. Caudal to the intervenous tubercle, fossa ovalis of about 0.3 x 0.5 cm in size could be distinctly noticed as a deep oval depression. A valve was identified at the opening of caudal vena cava in similar manner to that of human (Gray, 1918). Right coronary artery left ascending aorta, ran in the right coronary groove, and then terminated without giving subsinuosal interventricular branch. The subsinuosal interventricular branches ramified from the left coronary artery as found in majority of long-tailed monkey (Teofilovski-Parapid and Kreclovic, 1998). Therefore the coronary artery supply of the white-cheeked gibbon heart could be defined as left coronary type, which was similar to that found in dog and ruminant (Ghoshal, 1975<sup>a,d</sup>, Nickel et al., 1981; Dyce et al., 1996). Unlike in pig, horse, one-humped camel, ostrich, majority of human and bonnet monkey, subsinuosal interventricular branch rose from right coronary artery, which called bilateral coronary type (Ghoshal, 1975<sup>b,c</sup>; Buss et al., 1982; Bezuidenhout, 1984; Weaver et al., 1986; Ghazi and Tadjalli, 1993; Dyce et al., 1996; Agur and Lee, 1999).

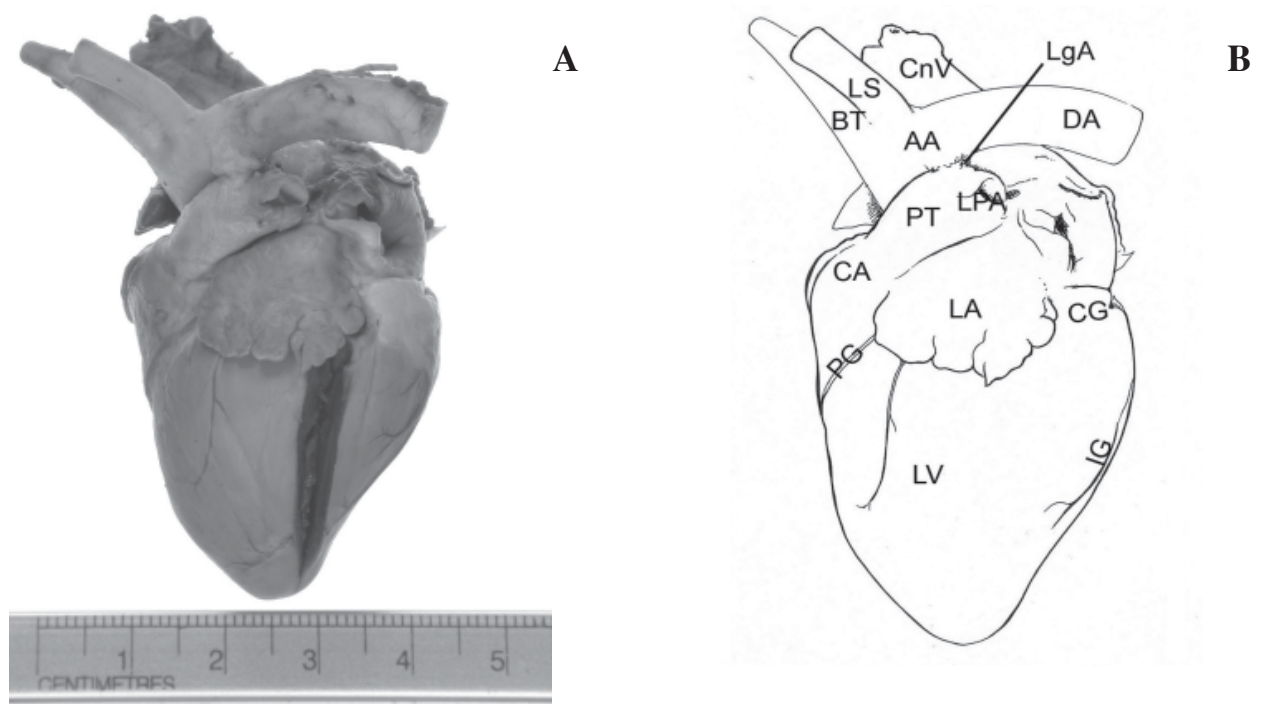
One septal and two parietal papillary muscles of 0.2 cm in diameter and 0.8, 0.7, and 1.5 cm in length,



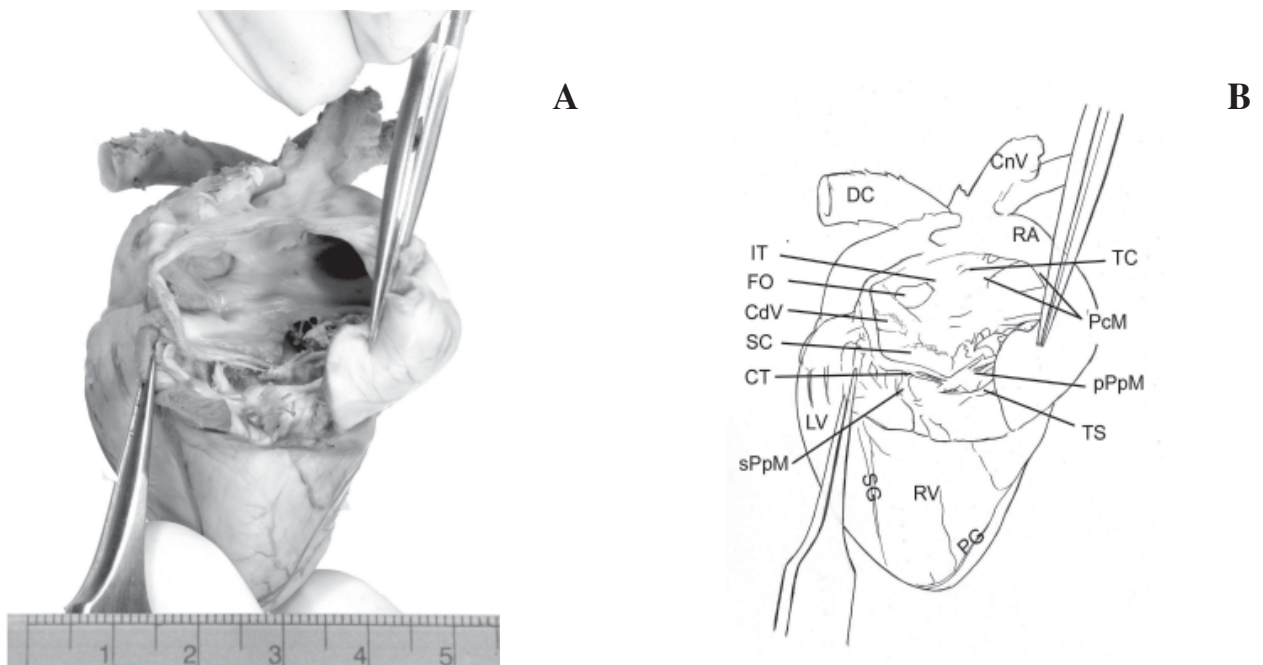
**Figure 1** Auricular surface (A) with schematic drawing (B): AA = aortic arch, BT = brachiocephalic trunk, CG = coronary groove, CnV = cranial vena cava, DA = descending aorta, LA = left auricle, LS = left subclavian artery, LV = left ventricle, PG = paraconal interventricular groove, PT = pulmonary trunk, RA = right auricle, RV = right ventricle; Scale bar shown in centimetres.



**Figure 2** Atrial surface (A) with schematic drawing (B): CdV = caudal vena cava, CG = coronary groove, CnV = cranial vena cava, DA = descending aorta, IG = intermediate groove, LA = Left auricle, LS = left subclavian artery, LV = left ventricle, PV = pulmonary vein, RA = right auricle, RV = right ventricle, SC = subsinoosal interventricular groove; Scale bar shown in centimetres.

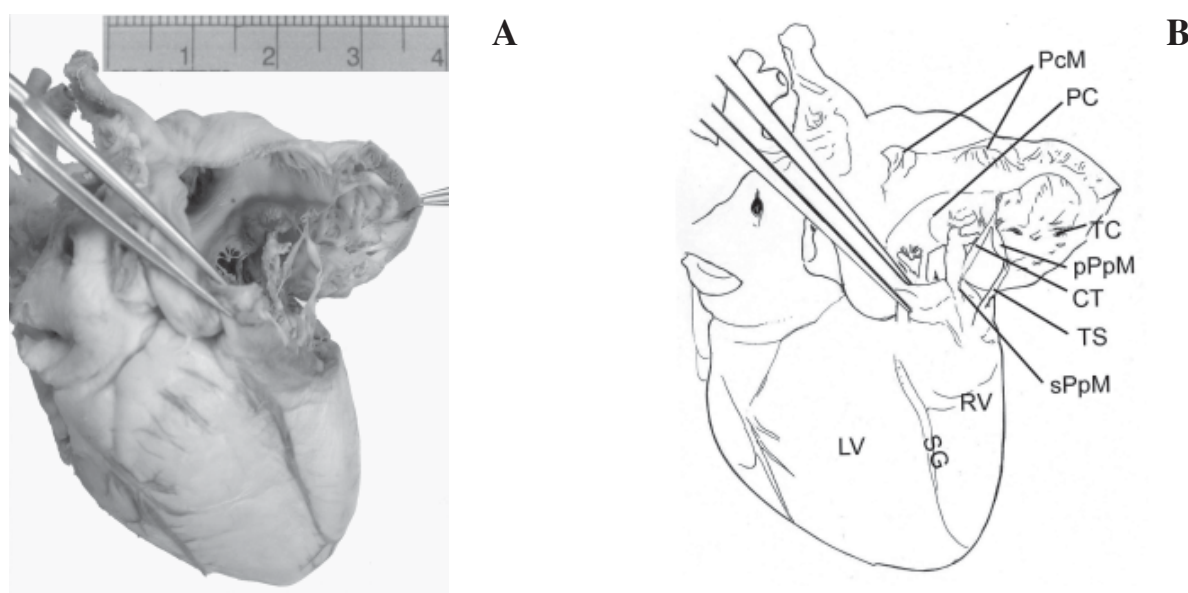


**Figure 3** Caudosinistral view (A) with schematic drawing (B): AA = aortic arch, BT = brachiocephalic trunk, CA = conus arteriosus, CG = coronary groove, CnV = cranial vena cava, DA = descending aorta, IG = intermediate groove, LA = Left auricle, LgA = ligamentum arteriosum, LPA = left pulmonary artery, LS = left subclavian artery, LV = left ventricle, PG = paraconal interventricular groove, PT = pulmonary trunk, PV = pulmonary vein; Scale bar shown in centimetres.



**Figure 4** Interior of the right atrium and ventricle (A) with schematic drawing (B) (right view): CdV = opening of caudal vena cava, CT = chordae tendinae, FO = fossa ovalis, IT = intervenous tubercle, LV = left ventricle, PcM = pectinate muscles, PG = paraconal interventricular groove, pPpM = parietal papillary muscle, RA = right auricle, RV = right ventricle, SC = septal cusp of right atrioventricular valve, SG = subsinuosal interventricular groove, sPpM = septal papillary muscle, TC = terminal crest, TS = trabecula septomarginalis; Scale bar shown in centimetres.





**Figure 5** Interior of the right atrium and ventricle (A) with schematic drawing (B) (cranial view): CT = chordae tendineae, LV = left ventricle, PC = parietal cusp of right atrioventricular valve, PcM = pectinate muscles, pPpM = parietal papillary muscle, RV = right ventricle, SG = subsinoventricular interventricular groove, sPpM = septal papillary muscle, TC = trabeculae carnae, TS = trabecula septomarginalis; Scale bar shown in centimetres.

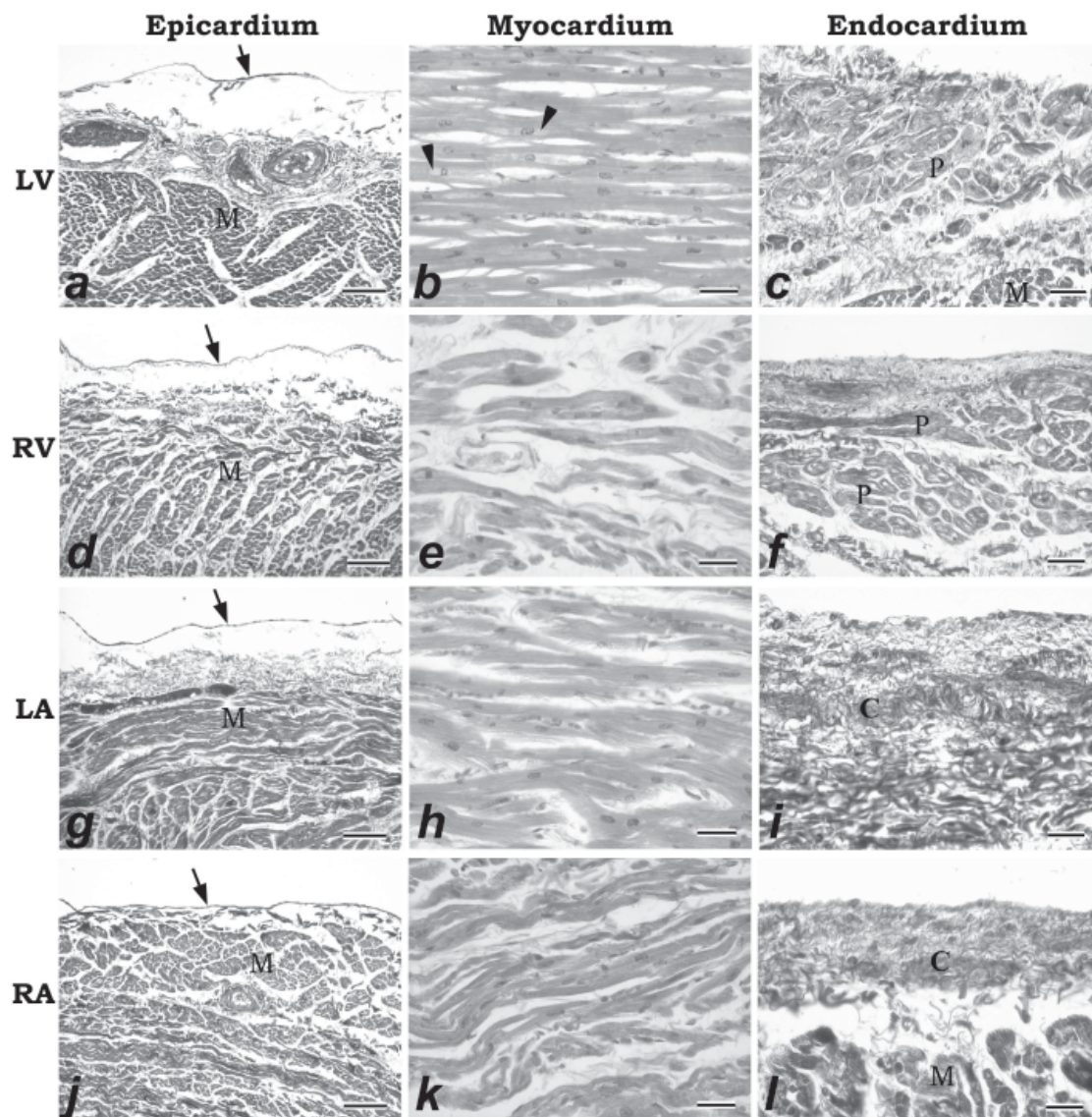
respectively, were identified in right ventricle. Three trabecula septomarginales with 0.05, 0.12, 0.2 cm in diameter and 0.5, 0.6, 0.3 cm in length, respectively, were found (Fig. 5). Pulmonary trunk with three semilunar cusps was 0.7 cm in diameter and 1.0 cm in length. Ligamentum arteriosum, the vestigial ductus arteriosus, connected the descending aorta to the junction between the left pulmonary artery and pulmonary trunk (Fig. 3). However, the ligament was found at the descending aorta and pulmonary trunk in dog and horse (Ghoshal, 1975<sup>a,b</sup>; Evans and Christensen, 1979)

#### ***Histological finding***

In the left ventricle, loose connective tissues containing small amount of collagen fibers, dispersing capillaries and nerve fibers were found underneath the mesothelium of epicardium (Fig. 6a). In addition, medium-sized blood vessels with clearly seen tunica adventitia were found interstitially in the deep epicardium. Typical characteristic of cardiomyocyte such as muscle striation, zyncytium and intercalated discs were commonly seen (Aughey and Frye, 2001) as shown in figure 6b. Nucleus could be ranging from normal, enlarged to

pyknotic with either round, oval, or irregular in shape. Binucleated cells can also be observed. Pale staining areas were seen at the poles of the nucleus could be the accumulation of mitochondria (Rhodin, 1975). Endocardium was thick with the number of large Purkinje fibers and subendocardium connective tissues (Fig. 6c). Subendothelium was thin and mostly occupied by elastic fibers as seen in dog (Wheater et al., 1987).

Epicardium of the right ventricle was similar to that in the left ventricle except its thickness and medium-sized blood vessels (Fig. 6d). The cardiomyocytes mostly with oval nuclei were quite dispersing and poor in regular arrangement (Fig. 6e). Number of Purkinje fibers in the endocardium was similar to the left ventricle (Fig. 6f). Epicardium of the left atrium was rich in connective tissues but not nerve (Fig. 6g). Histology of myocardium was similar to that in the left ventricle (Fig. 6h). However, Purkinje fibers were loosely distributed in the subendocardium (Fig. 6i). When compared with the others, the least amount of connective tissues was found in the right atrium (Fig. 6j). It was quite interesting that myofibrils and cross striation were



**Figure 6** Microscopic finding of the heart: LV = left ventricle (a, b, c); RV = right ventricle (d, e, f); LA = left atrium (g, h, i); RA = right atrium (j, k, l); epicardium (a, d, g, j: trichrome), myocardium (b, e, h, k: H&E), endocardium (c, f, i, l: trichrome) arrow = mesothelium, M = myocardium, arrowhead = mitochondrial area at the nuclear pole of muscle cells, C = impulse conducting fibers, P = Purkinje fibers. Bar = 50  $\mu$ m (a, d, g, j), 25  $\mu$ m (b, c, e, f, h, i, k, l)

less in myocytes of the right atrium (Fig. 6k). The amount of endocardial connective tissues was less than in the left atrium but arranged in larger bundles. The thinner endocardium composed of structures similar to the thicker counterpart in the left atrium (Fig. 6l).

In conclusion, some distinct anatomical characteristics but unlikely in histological results of the white-cheeked gibbon heart could be fundamental and beneficial for further investigation.

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