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Gross and morphometrical studies on the heart of Uttara fowl

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Abstract
The present study was carried out on 24 birds of different age groups of Uttara fowl and elucidates the age-related changes in the heart through gross morphological and gross morphometrical studies. The birds were reared and procured from the Instructional Livestock Farm (ILF), GBPUA&T, Pantnagar and were divided into four age groups viz. day old, 7, 28 and 112 days old. The present research study was undertaken for a period of four months from January, 2017 to April, 2017. Gross morphological studies revealed that the heart of Uttara fowl was located in the cranial part of thoracoabdominal cavity was enclosed by semi-transparent pericardial sac. The shape of the heart of Uttara fowl was like a cone with pointed apex and wide base. As the age advanced this cone becomes less pointed towards the apex. The colour of heart was brownish red which become darken with increase in age. Gross morphometrical studies revealed that there was a gradual increase in body weight of bird which was 37.03±1.58, 49.05±1.21, 179.16±9.16 and 1013.33±58.97grams at the day old, 7, 28 and 112 days respectively. The weight of heart at day old, day 7, day 28 and 112 day bird was 0.32±0.02, 0.43±0.03, 1.52±0.04 and 4.97±0.3 grams respectively, which was around 0.86%, 0.87%, 0.84% and 0.48% of the total body weight of bird at respective age intervals. The length of heart at day old, 7, 28 and 112 days Uttara fowl was 12.41mm, 13.11mm, 23.46mm and 31.71 mm respectively indicating that there was a gradual increase in length of heart from day old to 112 days old bird. Further, the thickness of the ventricular wall also increased with the advancement of age of the birds.

Keywords: Gross, morphometry, heart, Uttara fowl

Introduction
Uttarakhand has a great diversity of flora and fauna. The poultry population of Uttarakhand state is 26.01 lakh which has increased by 7.01% per annum while the population of desi fowl in the state decreased 28.67% from 2003 to 2007 [13]. The per capita annual egg and meat consumption in the state is 26 eggs and 1.15 kg/head which are less than national level as well as the recommended level of Indian council of medical research (ICMR) [3]. There are many species of birds reared in Uttarakhand. One of the local breed of bird found in Uttarakhand is Uttara fowl. It is generally reared under backyard system in Kumaon division of Uttarakhand state. It is of local importance in the region as it gives nutritional as well as economic security to the rearing families [8]. Local hill fowl meat is more chewy and tasty and is very popular among hilly rural areas [4]. The circulatory system comprises both the blood and lymphatic vascular systems. The blood vascular system is composed of the following structures, the heart which pumps the blood, the arteries which carry the blood with nutrients and oxygen to the tissues, the capillaries by which the interchange between blood and tissues takes place and the veins which convey the blood to be pumped again to heart [2]. In most birds the heart is located in the left median line of thoracic cavity and nearly parallel to the longitudinal axis of the body. Pericardial sac surrounds the heart and heart is four chambered two atria and two ventricles. Right atrium is normally larger then left whereas the left ventricle is three times larger than right and is thicker**.** In the avian heart the right and left atrioventricular (AV) valves not only exhibit their own special anatomical characteristics, but they also are in close proximity to the conduction system. The right AV valve is a single, spiral plane of myocardium. The left AV valve consists of three leaflets instead of the two typical of mammalian hearts**.** The specialized elements of heart comprise the sinu-auricular node which is situated beneath the epicardium at the base of the right venous valve, Sub-endocardial Purkinje network of both auricles, Auriculo-ventricular node which is situated in the lower and

posterior part of the auricular septum, the auriculo-ventricular bundle passes from the lower end of the auriculo-ventricular node, Sub-endocardial Purkinje network of both ventricles, recurrent branch of the auriculo-ventricular bundle and right auriculo-ventricular Purkinje ring. The structural characteristic of avian heart has not been fully investigated and the influence of wide range of factors on avian cardiac structures has yet to be examined. Due to availability of the scanty literature on the heart of the Uttara fowl, this present work was undertaken with an objective to study the age wise changes in the gross and morphometric parameters of the heart of Uttara fowl.

Materials and Methods

The present study was carried out on 24 birds of different age groups of Uttara fowl and elucidates the age-related changes in the heart through gross morphological and gross morphometrical studies. The birds were reared and procured from the Instructional Livestock Farm (ILF), GBPUA&T, Pantnagar and were divided into four age groups viz. day old, 7, 28 and 112 days old. The present research study was undertaken for a period of four months from January, 2017 to April, 2017. Gross morphology and morphometry of various parts of Heart were carried on fresh and unfixed specimens immediately after slaughter of bird. The weights of heart were registered using a digital balance (Sartorius, TE 214 S). Different gross parameters investigated were:

- Body weight of bird at various age intervals.
- Total weight of heart at various age intervals.
- Percent weight of the heart with respect to total body weight at various age intervals.
- Total length of heart at various age intervals.
- Width of base of the heart.
- Width of apex of heart.
- Thickness of the ventricular wall.
- Thickness of the interventicular septum.

Statistical analysis

The data was analyzed by applying Student's "T" test for comparison in 2 parameters and 'one way ANOVA' for comparison in three parameters to compare area related variables within different age groups.

Results and Discussion

The structural characteristics of Uttara fowl heart were examined in present study to evaluate the age related gross morphological and gross morphometrical changes in heart of Uttara fowl. Apparently healthy Uttara fowl birds of day old, 7, 28 and 112 days were procured from Instructional Poultry Farm, Nagla and their heart was collected from apparently healthy birds to perform various studies (Fig. 1).

Gross morphological studies

a. Pericardium

In the present study the pericardial sac was semitransparent, fibrous sac attached to surrounding structures. The caudal tip of the pericardial sacwas like a ligament and attached to the ventral mesentery of the liver. This ligament was located between the lobes of the liver and also attached to the ventral abdominal wall. A lubricating pericardial fluid was present in the space between the visceral and parietal pericardium. This finding was similar to domestic fowl [9]. The pericardium was attached to the dorsal surface of the sternum and surrounds air sacs and fixed tightly to the liver [10]. According to Strukie (1986), a small amount of lubricating serous fluid is present for rhythmic movement of cardiac contraction cycle.

b. Heart

Under gross morphological studies the heart of Uttara fowl was present in the pericardial sac located cranially in thoracoabdominal cavity in all the age groups of Uttara fowl. The axis of heart was aligned caudoventrally. These findings were supported by the findings in domestic fowl [9]. The heart of most birds is located in the thorax slightly left to the median line and is almost parallel to the longitudinal axis of the body, except that the apex was bending to the right [11]. The heart was located in the cranial part of the thoracoabdominal cavity with its long axis slightly attached to the right of the midline and it is enclosed dorsally and laterally by the lobes of the liver [10]. Avian heart is relatively larger than the mammalian heart, enclosed by pericardium and lies within the cranial part of cavum cardio abdominal [6]. Its long axis is slightly deflected to the right of the midline and it runs from craniodorsal to cranioventral. The base of the heart was directed craniodorsally and located at the level of second rib, while the apex of heart points towards the sternum and was situated on the transverse plane passing between the fifth and sixth rib. It was attached to various visceral organs like lungs, oesophagus, liver and proventriculus.

In the present study, the shape of 112 days old Uttara fowl heart was like a cone with pointed apex and wide base (Fig. 1). The color of heart was brownish red and as the age of the bird advanced the color of heart darkens. The cranioventral surface was smooth and convex and it had longitudinal groove upon which the coronary artery and vein travelled. These coronary arteries gave various branches which covers the whole surface of heart. The caudo-dorsal surface of heart was smooth and flat having marking of longitudinal groove in all the age groups. At the base of the heart a large amount of fat was present in all the age groups. The apex of heart was pointed and as the age advanced the cone becomes less pointed towards the apex with concavity on left side and convexity on right side (Fig. 1). This study was similar to the finding of Sisson and Grossman (1975).

c. 1. Surface

The shape of heart was elongated cone and as the age of the bird advanced the width of heart increased more compares to increase in length (Fig. 1). Both right and left margins of the heart were rounded. Similar finding were also reported by [9]. In all the age groups the heart was having three surfaces i.e. Sternal or cranioventral, Hepatic or caudodorsal and pulmonary or dorsal surface. At hepatic surface the caudal vena cava entered into the heart. The heart was surrounded abundant subepicardial fat which was present in the periphery of the coronary sulcus. The fat surrounded the atria, ventricles, surface veins and proximal part of the great vessels. Atrium and ventricles were clearly separated by coronary sulcus. The atrial walls rested on ventricular myocardium. The shape of the sternal aspect of the heart was elongated cone as reported in fowl [6]. Right and left margins of the heart were rounded. The right margin was significantly concave. The sternal surface was convex whereas the hepatic surface was flatter. The interventricular boundary was not clear. Cranioventrally the atria were separated from one another and are hidden by the pulmonary trunk, aorta, and brachiocephalic arteries. The auricles of the atria were not projected cranial to the pulmonary trunk and aorta.

In the present study the heart was surrounded by a pericardial sac filled with serous pericardial fluid. According to Kumar *et*

al. (2014), the pericardial sac was very thin fibrous layer which enclosed the heart having serous fluid. The function of this serous pericardial fluid was to provide lubrication for the rhythmicity of the cardiac contractions.

b. 2. Cardiac chambers

In the present study we found that the avian heart was divided into two atria and two ventricles (Fig. 2 and 3). It was found in the study of [7] that the avian heart has four chambers that are divided into two atria and two ventricles. And similar finding was observed by [9] and [11].

b. 3. Sinus venosus

In the present study it was found that the sinus venosus was not a separate chamber, but part of the right atrium and it was typical in the heart of day 112 age group of the Uttara fowl. The sinus venous was the extended chamber which was made by the fusion of the end parts of two cranial venae cavae and the caudal vena cava. The right and left hepatic veins that united in the end part of caudal vena cava forms the wall of sinus venosus. The sinuatrial valve and the chamber of the sinus venosus were clearly observed from the interior side of the right atrium. It was also found same in the study of [9] and [10].

b. 4. Right atrium

In the present study the right atrium was found much larger than the left atrium (Fig. 2 and 3). Similar finding was also observed by [7, 9, 10] in chicken. Same observation was found in Ostrich by [12]. Radiating pectinate muscles were present in the wall of the right atrium. The chamber of the sinus venosus opened in the right atrium which was guarded by sinuatrial valve. Whereas in the study of [9] it was observed that the left cranial vena cava does not open into the sinus venosus directly; apart from it opens into the right atrioventicular opening dorsally. Interatrial septum was present slightly oblique towards the left and its dorsal part was merged with the wall of right pulmonary vein. On ventral aspect, it was found that the right atrium was everted towards the left caudo-dorsally to the origin of the aorta and pulmonary trunk. The cone shaped floor of the right atrium opened into the crescent shaped right atrioventricular opening (Fig. 4). The floor of right atrium was medially formed by the right side of the interventricular septum.

In the day 112 old age group of Uttara fowl birds the sinus septum was observed that over lied the opening of left vena cava. The orifices of the right cranial vena cava are surrounded by the cranial part of the sinuatrial valve and it was slightly differentiated from the orifices of the caudal vena cava by a thin band of myocardium. The orifices of the right cranial vena cava were supported by malformed valvular arrangement. The dorsal cardiac vein orifice was cranial to the orifice of left cranial vena cava. The opening of the left cardiac vein was ventrocaudal to the opening of the left cranial vena cava. Similar findings were also observed by [9] and [10].

b. 5. Left atrium

In the present study it was found that the left atrium was smaller than the right atrium (Fig. 7, 12 and 13). The present study was in agreement with the findings of [7, 9, 10]. The left and right pulmonary vein entered the left atrium separately and abruptly merges into single vessel enclosed into the left atrium. The end part of the left cranial vena cava moves across the dorsal part enclosed segment. The end part of left cranial vena cava forms important part of dorsal wall of left atrium which is covered by atrial musculature. The common pulmonary vein projected into the left atrioventricular opening; the left side of the projection moves ventrally and to the left as free crescent shaped margin. The projected parts right and cranial aspects were fused with interatrial septum. The left free margin function as valve i.e. valve of the pulmonary vein. Dorsally to the valve of the pulmonary vein there is thin part of interatrial septum. The interatrial septum is formed by fusion of the pulmonary vein and left cranial vena cava in the left atrial wall and interatrial septum. The left atrial wall appeared fenestrated and had uniform secondary tertiary pectinate muscles than the right atrium (Fig. 6). The left atrioventricular opening was rounded. The similar finding was also observed by Sisson and Grossman (1975).

b. 6. Right ventricle

In the present study the right ventricle extended from the right atrioventricular opening towards the apex of the heart. The thickness of the wall of right ventricle was two to three times thinner than that of the right ventricle. Similar finding was also observed by [7]. In chicken heart the wall of right ventricle was three to four times thinner than the left ventricle [9]. The right ventricle slightly wraps the left ventricle. The conus arteriosus was the cone form cranial sub chamber of the right ventricle governs the pulmonary artery. The right ventricle expanded two third of the distance from the coronary sulcus to apex. The right atrioventricular opening was semilunar shaped; laterally it was surrounded by the right atrioventricular valve and interventricular septum medially. The right atrioventricular valve was musculature consisted of an inner lamina of thin atrial musculature made the septal part of the valve; the outer lamina of the valve was towards the ventricular muscles. The ventricular aspect of the valve divided from the right dorsal region of interventricular septum. The thick border of the valve was invaginated with basal of the right ventricle which form cavity in the free ventricular wall and outer surface of valve. The ventral end of valve had free cranial border; the valve redistribute and unite with the inner wall of the ventricle. At the root of the pulmonary artery three different pulmonary sinuses shows the location of the semilunar cusps of the pulmonary valve.

b. 7. Left ventricle

In the present study the left ventricle extended from the left atrioventricular opening towards the apex of the heart. The thickness of the wall of left ventricle was two to three times thicker than that of the right ventricle. Similar finding was also observed by [7]. The chamber of the left ventricle was elongated as well as cylindrical; characterized by presence of longitudinal trabeculae carnae in left ventricular wall (Fig. 5). Trabeculae carnae towards the apex of the heart merged into band like structures called papillary muscles (Fig. 5). Some fibers like structures move from the papillary muscles towards the cusps of the left atrioventricular valves called chordae tendineae. Each muscular cusp receives chordae tendineae from each papillary muscle. The left ventricle was cone shaped and its right wall forms the interventricular septum. The similar finding was also observed by [10]. In the left ventricle of day 112 old age group of Uttara fowl birds there were some tendinous moderator bands close to the apex that extend from septum to parietal wall and between trabeculae carneae of parietal wall. Same observation was found by [12] in Ostrich.

b. 8. Interventricular septum

In the present study the interventricular septum was observed between the right and left ventricle which divided the ventricle into two unequal chambers (Fig. 6). It was a dome shaped partition with ventral, lateral and dorsal aspects. The interventricular septum is present obliquely, where the convex surface remain towards the right ventricle and the concave surface towards the left ventricle. The cranial portion of interventricular septum was much thinner than its greater part. Similar observation was found by [7] in case of avian heart.

Grossmorphometric studies

In present study, the body weight and weight of heart were recorded at day old, 7, 28 and 112 days. There was a gradual increase in body weight of bird which was 37.03±1.58, 49.05±1.21, 179.16±9.16 and 1013.33±58.97grams at the day old, 7, 28 and 112 days respectively (Table. 1). While [1] reported that the body weight of squab pigeon was 13.833±0.86 grams, and body weight of mature racing pigeon was 307.43±48.34 grams and [5] reported the body weight of female and male emu bird was 40.94±5.35 and 33.92±4.74 kg respectively. While [6] stated that the avian heart is relatively much larger than that of mammals. It accounts for 0.5-1.42% of body weight in domestic fowl, in the turkey for 0.5%, in the duck and goose for 0.8% and in the pigeon for 1.1-1.4% of the body weight.

There was a gradual increase in weight of heart with the advancement of age. The weight of heart at day old, day 7, day 28 and 112 day bird was 0.32±0.02, 0.43±0.03, 1.52±0.04 and 4.97±0.3 grams respectively (Table. 1), which was around 0.86%, 0.87%, 0.84% and 0.48% of the total body weight of bird at respective age intervals.

The length of heart at day old, 7, 28 and 112 days Uttara fowl was 12.41mm, 13.11mm, 23.46mm and 31.71 mm respectively indicating that there was a gradual increase in length of heart from day old to 112 days old bird (Table. 2). The width of heart at the level of base was 6.58mm, 7.93mm, 12.64mm and 20.89 mm in day old, day 7 day 28 and 112 Uttara fowl. Similarly the width of heart at the level of apex was 3.78mm, 3.95mm, 7.57mm and 8.32 mm (Table. 2). In all the age groups the width of base of heart was more than the width of apex of heart and there was a gradual increase in width with the advancement of age. Statistically, the difference in width of apex and base in day old and day 28 Uttara fowl was non-significant ($P>0.05$) but it was significant ($P\leq0.05$) in day 7 bird and highly significant ($P\leq0.01$) in day 112 Uttara fowl.

In the present study the thickness of interventricular septum at day old, 7, 28 and 112 days Uttara fowl was 1.29mm, 1.41mm, 2.43mm and 4.12mm respectively indicating that there was a gradual increase in thickness of interventricular septum of heart from day old to 112 days old birds. The thickness of right ventricular wall at day old, 7, 28 and 112 days Uttara fowl was 0.72, 0.83, 1.03 and 2.13mm respectively indicating that there was a gradual increase in thickness of right ventricle of heart from day old to 112 days old bird. The thickness of left ventricular wall at day old, 7, 28 and 112 days Uttara fowl was 1.51mm, 1.61mm, 2.82mm and 5.02mm respectively indicating that there was a gradual increase in thickness of left ventricular wall of heart from day old to 112 days old bird.

Table 1: Body weight and total weight of heart at different age groups (Mean±SE)

Age group	Weight of bird (g)	Weight of heart (g)
Day old	37.03±1.58	0.32±0.02
Day 7	49.05±1.21	0.43±0.03
Day 28	179.16±9.16	1.52±0.04
Day 112	1013.33±58.97	4.97±0.3

Table 2: Total length of heart and width of apex and base (mm) at different age groups of Uttara fowl (Mean±SE).

Age group	Length (mm)	Width of base (mm)	Width of apex (mm)
Day old	12.41±0.61	6.58±0.33	3.78±0.34
Day 7	13.11±0.3	7.93±0.34*	3.95±0.09*
Day 28	23.46±0.45	12.64±0.17	7.57±0.23
Day 112	31.71±0.5	20.89±0.43**	8.32±0.82**

$P>0.05$, * significant ($P\leq0.05$): ** highly significant ($P\leq 0.01$): Different superscript within rows indicates significant and highly significant difference between width of apex and base

Fig 1: Photograph showing heart of day old, day 7, day 28 and day 112 Uttar fowl

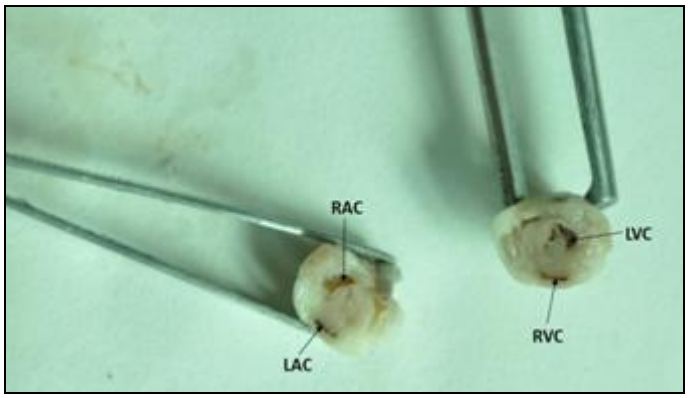

Fig 2: Photograph showing right atrial chamber (RAC), left atrial chamber (LAC), right ventricular chamber (RVC) and left ventricular chamber (LVC) in the cross section of the heart in day 28 Uttara fowl

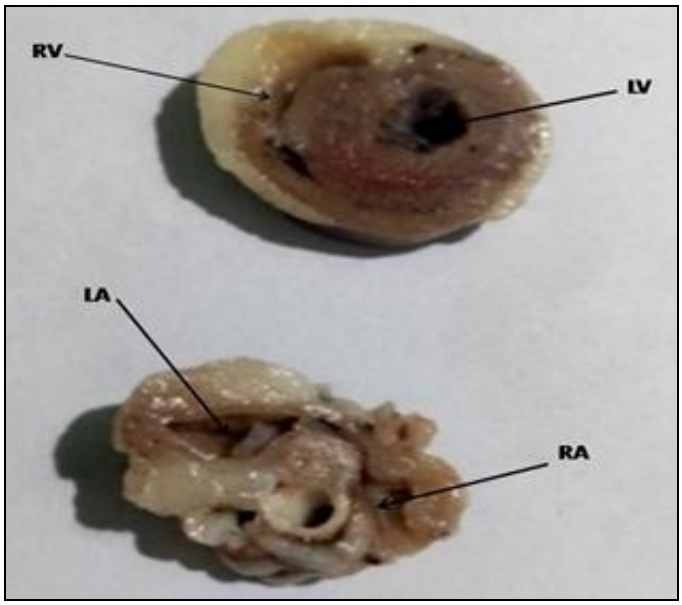

Fig 3: Photograph showing right atrium (RA), left atrium (LA), right ventricular chamber (RV) and left ventricular chamber (LV) in the cross section of the heart in day 112 Uttara fowl

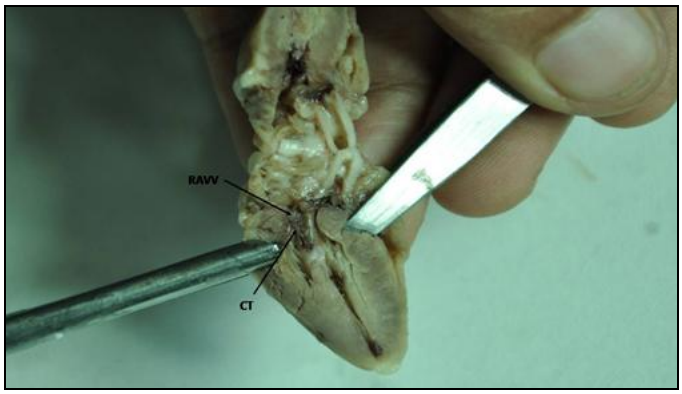

Fig 4: Photograph showing right atrioventricular valve (RAVV) and chordae tendineae (CT) in day 112 Uttara fowl

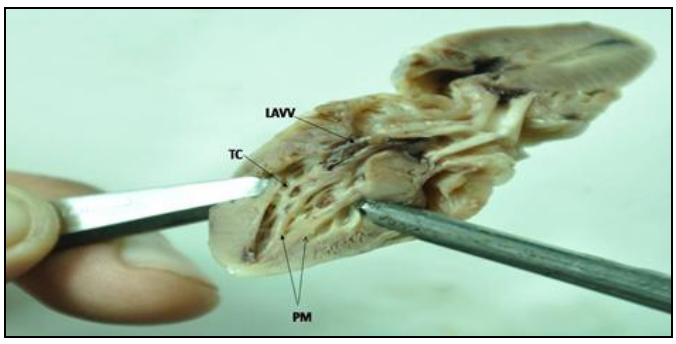

Fig 5: Photograph showing left atrioventricular valve (LAVV), trabeculae carnae (TC) and papillary muscles (PM) in day 112 Uttara fowl

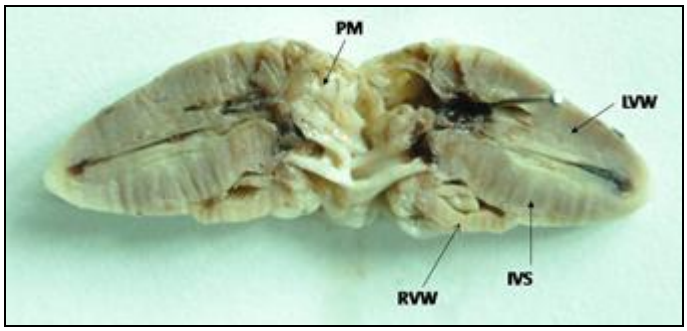

Fig 6: Photograph showing pectinate muscles (PM), interventrcular septum (IVS), right ventricular wall (RVW) and left ventricular wall (LVW) in day 112 Uttara fowl

Conclusion

The present study showed that the heart of Uttara fowl was located in the cranial part of thoracoabdominal cavity which was enclosed by semi-transparent pericardial sac. The caudal tip of the pericardial sac was like a ligament and attached to the ventral mesentery of the liver. The shape of the heart of Uttara fowl was like a cone with pointed apex and wide base. There was gradual increase in the body weight of the birds as well as the weight of the heart, length of the heart, width of the base and apex of the heart with the advancement of age. Statistically, the difference in width of apex and base of the heart in day old and day 28 Uttara fowl was non-significant ($P>0.05$) but it was significant ($P\leq0.05$) in day 7 birds and highly significant ($P\leq0.01$) in day 112 Uttara fowl birds.

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