

## Gross Anatomical Studies on Normal Heart of Buffalo (*Bubalus bubalis*)

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### ABSTRACT

The present research work involved the anatomical account of heart of buffaloes. For this purpose, one hundred normal fresh hearts, 50 each from male and female buffaloes of different ages were randomly collected from the slaughter house of Mirpurkhas city. According to their age and sex, the animals were divided into four i.e. A1 (young male, 1 - 2 years), A2 (young female, 1 - 2 years), B1 (adult male, 3 - 6 years) and B2 (adult female 3 - 6 years). The mean age of buffaloes A1, A2, B1 and B2 groups ranged from 1.2 - 4.2 years. The mean length of anterior border base to apex of heart of buffaloes was 13 - 15.8 cm. Significant increases in the mean length of anterior border base to apex of the heart and between right and left coronary grooves of heart were observed in adult animals as compared to young animals. The mean length of posterior border from base to apex of heart was 11.8 - 13.9 cm, while a significant increase was observed in the mean length of posterior border base to apex in young males as compared to young females. A significant increase was observed in the mean weight of the heart of male and female buffaloes as the age of animal advances.

**Key Words:** Heart; Gross anatomy; Biometry; Buffalo

### INTRODUCTION

The water buffalo (*Bubalus bubalis*) is a species with great potential for work and for meat and milk production in Pakistan. Buffalo is very popular animal and it has been known as Riverian type. Traditionally, buffaloes were raised by small farm holders for multipurpose in agriculture production. Water buffaloes are well suited to poor feeding management as well as adapted to the hot-humid tropical climatic conditions. Buffalo is also considered a friend of farmer family not only for draught power and fertilizer but also for take full advantage of feeds resources, free time and subsidiary labors etc. of small farm holder in rural area.

Heart is reddish-brown in colour. The size of heart is 29.25 cm x 20.40 cm. The heart lies in the lower anterior part of the chest cavity between the lungs but projecting more to the left side to the right and is enclosed with a sac called pericardium. Its base lies opposite to the 3<sup>rd</sup> and 6<sup>th</sup> ribs inclusive and its apex lies above the last segment of sternum. The atrium from the two ventricles is a circular or coronary groove also carrying blood vessels. Both grooves are usually filled with fat in well-nourished animals (Groves, 2003). The normal heartbeat of the ox is 45 - 60 per min. Its average weight is about 2.5 kg or ranging 0.4 to 0.5% of the total body weight. It pumps about 4000 gallons blood daily. The circulatory system contains (i) pulmonary circulation (ii) systemic circulation and (iii) fetal circulation.

Heart performs the functions such as electric, acoustic, pressure, flow and volume changes. Heart cycle is divided into two principle phases; (i) Ventricular contraction: It is shorter period and its duration is altered only slightly regardless of increased heart rate and (ii) Ventricular relaxation: It is longer during the lowest heart rate but progressively shortens during cardiac acceleration and it almost appears at maximum heart rate.

As for as Indo Pak subcontinent is concerned, there is a great need to carry out research work on the indigenous breeds of animals. Most of the research work on anatomy is carried out in other region of the world on exotic or crossbred animals. Therefore, the aim of the present study is directed toward anatomical investigation of the heart of the indigenous breeds of buffalo, as there is dearth of literature on the anatomical account on the heart of the indigenous breeds in this country. As such it was considered necessary to undertake the present study for comparative anatomy and for applications in the fields of cardio physiology and pathological studies.

### MATERIALS AND METHODS

One hundred normal fresh hearts of commercially slaughtered buffaloes of different ages were randomly collected from slaughterhouse of Mirpurkhas city, sindh province and packed into polythene bags and brought to the

Departmental laboratory. The heart specimens were distributed into two main groups A and B, 50 contained in each group. The group A was again divided into two sub groups A1 (young male) and A2 (young female), while group B was similarly divided into two groups B1 (adult male) and B2 (adult female) contained 25 hearts in each. The estimated age of animals of group A1 was 1 - 2 years, A2, 1 - 2 years and group B1, 3 - 6 years and B2, 3 - 6 years. The age of animals was recorded through their incisor teeth as described by Braun *et al.* (1999) just before the slaughter of the animals at slaughterhouses. No gross pathological lesions were observed in hearts. Before taking the measurements, all un-necessary tissues and fat deposits were removed. The hearts were cleaned and freed from extra adhering tissues and were placed on surgical table in their normal position. The organs were weighed by triple beam balance in gram and the following parameters were recorded in centimeters by using tailor tape measure.

1. Length of anterior border base to apex.
2. Length of posterior border base to apex.
3. Circumference at the coronary grooves.
4. Distance between right and left coronary grooves.
5. Distance between right coronary grooves to apex.
6. Distance between left coronary grooves to apex.
7. Distance between caudal vena cava to apex.
8. Distance between caudal vena cava and the origin of pulmonary artery.

**Statistical analysis.** The data collected regarding biometry of heart were arranged in tabular forms and statistically analyzed as per MSTAT-C Microcomputer program. Furthermore, the measurements were analyzed and the significant difference between the means was also recorded.

The correlation of the measurements of the heart of the buffaloes with age and sex was also carried-out.

## RESULTS

**The mean approximate age of young male, female and adult male, female buffaloes determined through their incisors during study.** The mean age of male and female of young and adult buffaloes determined by their incisors during present investigation is summarized in Table I. According to their age, the animals were divided into four groups i.e. A1, A2, B1 and B2. The groups A1 and A2, those contained the young male and female buffaloes with their first pair of incisors, the mean age determined as  $1.2 \pm 0.08$  (range 1 - 2 years) and  $1.64 \pm 0.13$  (range 1 - 2 years), respectively while animals of groups B1 and B2 contained adult male and female with 2 - 4<sup>th</sup> pair of incisors, the mean age was determined as  $4.2 \pm 0.19$  (range 3 - 6 years) and  $3.9 \pm 0.91$  (range 3 - 6 years), respectively.

**The mean weight of the heart of buffaloes weighed during study.** The mean weights of hearts of male and female buffaloes are summarized in Table II. The mean  $\pm$  S.E weight of the heart of young male buffaloes (group A1)

and female (group A2) animals was recorded as  $550.8 \pm 12.03$  gm,  $540.6 \pm 14.35$  gm, respectively while that of the adult male (group B1) and female (group B2) buffaloes was recorded as  $1284.7 \pm 59.62$  gm,  $954 \pm 36.75$  gm, respectively. During present investigation a significant increase was observed in the mean weight of adult male animals as compared to adult female as well as the young one of both the sexes. It means that, when the age of animal was increased the weight of heart also increased. A positive significant correlation of weight of heart was found in both male and female groups with their age and body weight, respectively (Table III).

**The mean length of anterior border base to apex of buffalo heart of different sex and age.** The mean length of anterior border base to apex of heart of buffaloes of different age and sex measured during this study is presented in Table IV. The mean length of anterior border base to apex of heart of young male buffaloes of group A1 was measured as  $13.9 \pm 0.22$  cm, while young female of group A2 measured as  $13.3 \pm 0.22$  cm, respectively. Whereas the mean length of anterior border base to apex of adult male and female buffaloes of group B1 and B2 was measured as  $15.4 \pm 0.023$  and  $15.8 \pm 0.28$  cm, respectively. The mean length of anterior border base to apex of the heart of adult animals increased significantly as the age of the animals advances.

**The mean length of posterior border base to apex of heart of different age and sex of buffaloes.** The mean length of posterior border base to apex of heart of buffaloes of different ages and sexes measured during present study is presented in Table IV. The mean length of posterior border base to apex of buffaloes of young male and female were recorded as  $12.1 \pm 0.21$  cm and  $11.8 \pm 0.28$  cm, respectively. While the mean length of posterior border base to apex of adult male and female buffaloes were noted as  $13.4 \pm 0.24$  and  $13.9 \pm 0.25$  cm, respectively. During the present investigation a significant increase was observed in the mean length of posterior border base to apex in young males and female as well as adult male as compared to adult female.

**The mean circumference at coronary grooves of heart of different age and sex of buffaloes.** The mean circumference at the coronary grooves of heart of buffaloes of different age and sex was presented in Table IV. The mean circumference at the coronary grooves of the heart of young male (group A1) and young female (group A2) buffaloes was measured as  $27.6 \pm 0.41$  and  $26.0 \pm 0.51$  cm, respectively. Whereas the mean circumference at the coronary grooves of adult male and female (group B1 & B2) buffaloes measured as  $31.1 \pm 0.48$  and  $33.5 \pm 0.54$  cm, respectively.

Generally, when these values were correlated with their age and sex in young animals, a significant increase was observed in the mean circumference at the coronary grooves in young males (Table V). Similar trend in the increase of circumference at coronary grooves of adult

**Table I. The mean age of different groups of male and female buffaloes determined on the basis of incisor teeth**

Groups	Eruption of permanent teeth	Approximate mean age in years
A1 (young male)	2 permanent incisors	1.2±0.08 (1-2 years)
A2 (young female)	2 permanent incisors	1.64±0.13 (1-2 years)
B1 (adult male)	4-8 permanent incisors	4.2±0.19 (3-6 years)
B2 (adult female)	4-8 permanent incisors	3.9±0.91 (3-6 years)

**Table II. The mean weight of heart of different age and sex of male and female buffaloes**

Groups	Weight ± S.E (Range)
A1 (young male)	550.8±12.03 (441.4-780.6)
A2 (young female)	540.6±14.35 (435-665)
B1 (adult male)	1284.7±59.62 (635-1595)
B2 (adult female)	954.5±36.75 (655-1357)

**Table III. The correlation analysis of weight of heart of different groups of male and female buffaloes with their age and sex**

Groups	"r" values	Remarks
A1 (young male)	0.580	**
A2 (young female)	0.752	**
B1 (adult male)	0.876	**
B2 (adult female)	0.894	**

r = correlation coefficient

\*\* = Highly significant

animals irrespective of their sex was also observed. It is concluded from this study that age, weight and breed have major role in the increase in the size of organ.

**The mean distance in between right and left coronary grooves of heart of buffaloes.** The mean distance in between right and left coronary grooves of heart of buffaloes measured during study is given in Table IV. The mean distance in between right and left coronary grooves of A1 and A2 groups measured as  $13.9 \pm 0.28$  cm and  $15.0 \pm 0.25$  cm, respectively whereas the mean distance between the right and left coronary grooves of B1 and B2 groups of adult animals measured was  $15.0 \pm 0.25$  cm and  $15.7 \pm 0.26$  cm, respectively. Increase trend was observed in the size of the heart in both sexes as the age of the animal advances. However, this increase was statically no significant in all experimental animals except adult male buffalo (Table V).

**The mean distance between right and left coronary grooves to apex of the heart of buffaloes.** The mean distance between the right and left coronary grooves to apex of heart measured and summarized in Table IV. The mean distance between right and left coronary grooves to apex of heart of young male buffaloes (group A1) measured was  $12.0 \pm 0.20$  cm and  $10.20 \pm 0.22$  and while young female (group A2) was  $10.9 \pm 0.25$  and  $9.6 \pm 0.19$  cm, respectively. On the other hand, the distance between the right and left coronary grooves of adult male (B1)

recorded was  $12.6 \pm 0.22$  cm and  $11.1 \pm 0.22$  cm and adult female buffaloes (B2) was  $12.8 \pm 0.33$  cm and  $10.8 \pm 0.31$  cm, respectively. During present study a significant increase between right and left coronary grooves of heart were observed in adult animals as compared to young animals (Table V).

**The mean distance between the termination of caudal vena cava and apex of heart of buffaloes.** The mean biometrical distance between caudal vena cava and apex of heart of buffaloes measured in this study is tabulated in Table IV. The mean distance between caudal vena cava and apex in young male (group A1) and female (group A2) was  $16.7 \pm 0.27$  cm and  $15.7 \pm 0.32$  cm, respectively. However, the mean distance between termination of caudal vena cava and apex of the heart of adult male (group B1) and female (group B2) buffaloes measured as  $18.0 \pm 0.27$  cm and  $18.0 \pm 0.29$  cm, respectively. The result obtained in present investigation showed a significant increase in the mean distance between termination of caudal vena cava and apex in young male as compared to young female. Furthermore, the finding of the present study also revealed a significant increase in the mean distance between termination of caudal vena cava and apex as the age of the animals advanced indicating that age has significant correlation with the size of caudal vena cava and apex in buffaloes.

**The mean difference between the origin of pulmonary artery and caudal vena cava of the heart of buffaloes.**

The mean biometrical distance between the origin of the pulmonary artery and caudal vena cava of heart of buffaloes presented in Table IV. The distance between the origin of pulmonary artery and caudal vena cava of young male (group A1) and female (group A2) animals was recorded as  $4.1 \pm 0.07$  cm and  $4.6 \pm 0.8$  cm, respectively while that of adult male (B1) and female (B2) buffaloes was  $5.7 \pm 0.08$  cm and  $5.4 \pm 0.09$  cm, respectively. During present study significant increase in the mean distance between origin of pulmonary artery and caudal vena cava was observed in adult as compared to young animals.

## DISCUSSION

**Age.** Braun *et al.* (1999) approximated the age of buffaloes with the eruption of 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> pair of incisors to be of 2.5 - 3, 3.5 - 4, 4 - 5 and 5.5 years, respectively. The approximate mean age of buffaloes determined in this study to record the biometrical values of heart was very similar to Braun *et al.* (1999). A little variation in the age determination of buffaloes between present study and that of Braun *et al.* (1999) was seen; this variation could have been due to breed, management and practices at farms. Furthermore, Keshaw (2000) devised a formula for age determination for large animals with the eruption of 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> pair of permanent incisors at the approximate ages 1.5 - 2.5, 3, 3.5, 4 - 5

**Table IV. The mean measurements of various parameters of heart of buffaloes of different groups measured during study period**

Measurements	A1 (young male years, N = 25)	1-2 A2 (young female years, N = 25)	1-2 B1 (adult male years, N = 25)	3-6 B2 (adult female years, N = 25)
Mean length of anterior border base to apex (cm)	13.9±0.22 (12.05-16.90)	13.3±0.33 (11.116.6)	15.4±0.23 (13.1-17.2)	15.8±0.28 (12.1-17.6)
Mean length of posterior border base to apex (cm)	12.1±0.21 (10.1-14.1)	11.8±0.28 (10.2-14.9)	13.4±0.24 (10.7-14.7)	13.9±0.25 (11.3-15.9)
Mean circumference at the coronary grooves (cm)	27.6±0.41 (23.0-32.0)	26.0±0.51 (22.4-32.0)	31.1±0.48 (25.3-35.7)	33.5±0.54 (28.0-38.0)
Mean distance between right and left coronary grooves (cm)	13.9±0.28 (12.0-17.1)	13.4±0.39 (11.4-18.5)	15.0±0.25 (12.1-16.6)	15.7±0.26 (12.1-18.0)
Mean distance between right coronary grooves to apex (cm)	12.0±0.20 (10.0-14.0)	10.9±0.25 (8.3-13.8)	12.6±0.22 (10.6-15.3)	12.8±0.33 (10-15.1)
Mean distance between left coronary grooves to apex (cm)	10.20±0.22 (9.0-13.1)	9.6±0.19 (7.9-11.5)	11.1±0.22 (8.08-13.2)	10.8±0.31 (8.01-13.01)
Mean distance between caudal vena cava and apex (cm)	16.7±0.27 (14.5-19.5)	15.7±0.32 (13.8-18.5)	18.0±0.27 (15.03-19.8)	18.0±0.29 (15.1-20.01)
Mean distance between origin of pulmonary artery and caudal vena cava	4.1±0.07 (4.0-5.3)	4.6±0.08 (3.9-5.0)	5.7±0.08 (5.0-6.02)	5.4±0.09 (5.0-6.1)

N = Number of observations

**Table V. The correlation among various variables of different parameters of heart of buffaloes with their age**

Variables	Group A1 "r" values (Young male)	Group A2 "r" values (young female)	Group B1 "r" values (adult male)	Group B2 "r" values (adult female)
Length of anterior border base to apex	0.605**	0.512**	0.677**	0.441*
Length of posterior border base to apex	0.463**	0.495**	0.590**	0.368
Circumference at the coronary grooves	0.455*	0.494**	0.544**	0.755**
Distance between right and left coronary grooves	0.351	0.332	0.550**	0.337
Distance between right coronary grooves to apex	0.631**	0.318	0.464**	0.594**
Distance between left coronary groove to apex	0.591**	0.342	0.552**	0.0564**
Distance between caudal vena cava to apex	0.432*	0.501**	0.625*	0.426*
Distance between the origin of pulmonary artery and caudal vena cava	0.571**	0.291	0.575**	0.533**

Values within each age group with different superscripts differ significantly ( $P < 0.001$  0.05).

years, respectively and this was also close to our findings. However the mean age determined for buffaloes in our study did not coincide with the age recorded by Leinders (1999), who calculated the age for cows. One should expect the breed variation, which can make some errors in calculating the actual age of the animals.

**Weight of heart.** Our findings for the mean weight of heart of buffaloes were in close agreement to that of Leinders (1996), Mohan and Prakash (1997), Miglino and Amorim (1998). They observed that the average weight of heart of ox that ranged from 1800 to 2500 gm, whereas Miller (2004) recorded the mean weight of heart of buffaloes as  $1175 \pm 23$  gm. According to West (1995), the weight of heart of buffalo ranged from 5 to 7 lb. The mean weight of heart observed for groups A1, A2, B1 and B2 of both male and female buffaloes of the present study are not in agreement with those reported by aforesaid workers. This could have been due to the age and breed variation.

**Length of anterior border base to apex of heart.** Though recorded, a relative dearth exists on the biometrical value of the mean length of anterior border base to apex of heart of adult buffaloes (Mohan & Prakash, 1997; Miller, 2004). The authors recorded the average length of anterior border base to apex as 18 cm, which was larger than the values for all groups in this study. Also, Sharma *et al.* (1998) measurement of the same parameter in the ox was somewhat larger than the measurements recorded in the present study. It is concluded from the study that age, breed and even species

have a major role in the mean length of anterior border base to apex of heart.

**Length of posterior border base to apex of heart.** Miller (2004) reported that the average length of posterior border base to apex of as 13.50 cm in adult buffaloes thus was closely related the findings in this study. Since the apex of the heart of other animals was somewhat in cone-shaped, so length was somewhat higher than the present study. Mohan and Prakash (1997) and Sharma *et al.* (1998) reported the ratio between the anterior and posterior borders was 13.9:11.8 cm.

**Circumference at coronary grooves of the heart.** According to Mohan and Prakash (1997) the circumference within the coronary grooves averaged 28.95 cm in buffaloes and 38.75 cm in cows, while Braun *et al.* (1999) recorded 37 cm the buffalo's heart. These observations were consistent with the results obtained in this study though at variance with the data obtained in young animals. It would thus be justified to work on specific age groups when recording actual circumference of the heart of buffaloes at coronary grooves.

**Distance in between right and left coronary grooves of the heart.** Mohan and Prakash (1997) observed that the distance between the right and left longitudinal grooves met at 4.02 cm above the apex of the heart on the right side. They also measured the distance between right and left coronary grooves from the point of start and union of these two grooves to each other as 4.45 cm. Unfortunately we measured from right to left but not at that point, where these two grooves meet each other as

recorded by the above authors and obtained 13.4 - 15.7cm.

**Distance between right and left coronary grooves to apex of the heart.** It is very difficult to compare the present results regarding right and left coronary grooves to apex of young and adult male and female buffaloes to the results of other workers because no such kind of studies have been carried out on buffaloes before. Braun *et al.* (1999) studied and measured the distance between right and left coronary grooves to apex in cows and obtained an average 15.0 cm, which was comparable with the results observed in this study.

**Distance between the termination of caudal vena cava and apex of heart.** The difference between the termination of caudal vena cava and the apex of the heart was 13.3 cm, lesser than the distance between the latter and origin of pulmonary artery at 16.96 cm Mohan and Prakash (1997), while Miller (2004) obtained 14.45 cm as the difference between the termination of posterior vena cava and the apex of the heart, which is smaller than the size recorded in the present investigation. Generally, the distance measured by the above authors was in close agreement with this study.

**Distance between the pulmonary artery and caudal vena cava of heart.** The findings regarding the above parameters in different groups of buffaloes with different age and sex are similar to that of Mohan and Prakash (1997), who obtained a value of 5.6 cm. Miller (2004) recorded similar observations in Indian adult buffaloes. It is concluded that if animals were selected from age just of two years, than that, there would be no big variation in the size of organs or their measurements.

This study provides important biometric information concerning the dimensions and weight of the heart of buffalo. Furthermore the results obtained will be valuable in comparative anatomy of the buffalo heart particularly for age and sex specific study and in applied fields of cardiophysiology and cardio pathology.

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