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## **Two dimensional and M-mode echocardiography in normal healthy Egyptian Zarabi Goats.**

By

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### **Abstract**

Echocardiography and intra-cardiac dimensions have not previously been reported in adult egyptian zarabi goats despite its potential application for medical purpose. The chests of 11 adult male goats were examined at 3<sup>th</sup> - 6<sup>th</sup> intercostal space on both sides of the thorax using 2.6-6 MHz convex transducer. All chambers of the heart were clearly visualized in the parasternal long axis view from both sides. The both ventricles and ventricular outflow with appearance of the aortic root is best to visualize from the right side at 4<sup>th</sup> RICS (right inter costal space) and the transducer rotate bet 0°to30°caudally. Left ventricle with papillary muscle, chordea tendenea, mitral valve, aortic valve and pulmonary artery views were visualized at 4<sup>th</sup> RICS (right inter costals space) 2 cm above elbow and the transducer rotate at different angles bet 0°to90° perpendicularly on inter costals space. During systole and diastole, dimensions of the left ventricle were greater than those of right ventricle, whereas size of the ventricles was significantly greater during diastole than systole ( $p>0.01$ ). The dimensions of the interventricular septum, left and right ventricular free wall were greater in systole than diastole.

**Key words : Echocardiography- Egyptian Zarabi goats**

### **Introduction**

The domestic goat (*Capra hircus*) is a subspecies of goat domesticated from the wild goat. The goat is a member of the family Bovidae and is closely related to the sheep as both are in the goat-antelope subfamily Caprinae. There are over 300 distinct breeds of goat. Goats are one of the oldest domesticated species, and have been used for their milk, meat, hair, and skins over much of the world. ( Coffey et al, 2008 )

Echocardiography is a good ancillary tool to assess the heart in other ruminant species. It is a non-invasive, straightforward method for assessment of the bovine heart **Hallowell et al, (2007)**. It has been used extensively in cattle and can be used as a prognostic tool in some diseases since the extension and importance of the disease are better assessed **Buczinski (2009)** and **Mohamed and Buczinski (2011)**. The procedure is a widely used imaging tool in small animals, horses and cattle for evaluation of morphologic changes, abnormal wall thickness, chamber size and valvular appearance and function **Reef (1990)**.

The aim of this a prospective study was to demonstrate normal cardiac appearance and normal chamber dimensions in adult Egyptian zarabi goats.

## **Material and Methods**

### **Material**

#### **Animals**

Eleven male adult Egyptian Zarabi Goat (age:  $22\pm 2.3$  monthes) and with (  $30\pm 1.8$ ) kg body weight. Their BCS ranged from 3.0 to 4.0. All goats received a full clinical examination According to **Kelly, (1984)** including general behaviour and condition, examination of the heart, lungs, rumen and intestines, detection of heart and respiratory rates and rectal temperature. and they had full access to feed and water before and after examination.

#### **Echocardiographic protocol**

Echocardiographic examinations were performed by A real time, B-mode , M- mode and Doppler array ultrasound scanner (**B7v** veterinary multi-purpose ultrasound scanner Noveko company made in Canada ) was used in this work. The scanner is provided with two transducer ( convex transducer 2.6 to 6 MHz)and (sector transducer 4 to 8 MHz).A black and white video graphic printer (up- 890 MD Sony<sup>®</sup>) was used for printing the frozen image. In preparation for the echocardiography, the intercostal spaces (3rd to 6th) on both sides of the thorax were clipped, shaved and swabbed with alcohol to remove excess oil, and coupling gel was applied. The third, fourth and fifth intercostal spaces in the cardiac region were examined ultrasonographically on the right and then the left sides of the thorax. The thoracic limbs were moved cranially to facilitate better contact between the probe and the intercostal space. The cardiac views obtained in this study are adaptation of those described for goat **Leroux, et al.,(2012)**.Four two dimensional (2-D) parasternal images were obtained from the right and three 2-D parasternal images from the left as described for cattle **Braun et al,(2011)**. Additionally, M-mode images were obtained from the right and left sides of the thorax. 2-D

images from both the right and left hemithorax were used to guide the placement of the probe and obtain accurate M-mode recordings. Coupling gel was applied to the transducer, and this was applied to the skin approximately in the 3rd and 4th and 5th right and left intercostal spaces.

### **Echocardiographic measurements**

Echocardiographic measurements were performed using the electronic ultrasound calipers.. Three non-consecutive cardiac cycles were measured and later measurements were averaged in order to eliminate some of the measurement errors. Eighteen measurements were recorded from the 2-D images. Left ventricular diameter in systole (LVs) and diastole (LVd) Right ventricular diameter in systole (RVs) and diastole (RVd), Left ventricular wall thickness in systole (LVWs) and diastole (LVWd) right ventricular wall thickness in systole (RVWs) and diastole (RVWd), interventricular septal thickness in systole (IVSs) and diastole (IVSd) and aorta in systole (Aos) and diastole (Aod). according to **Crippa. et al,(1992)**.

### **Echocardiographic Indices**

These indices were calculated using the following calculations as reported by **Bonagura (1983)**.

$$\mathbf{FS} = \frac{\text{LVID(d)} - \text{LVID(s)}}{\text{LVID(d)}} \quad (\text{FS} = \text{fractional shortening}).$$

$$\mathbf{EF} = \frac{\text{LVID(d)}^3 - \text{LVID(s)}^3}{\text{LVID(d)}^3} \quad (\text{EF} = \text{ejection fraction}).$$

**LVID d** (left ventricular internal dimension in diastole).

**LVID s** (left ventricular internal dimension in systole).

These indices can be employed to evaluate the true efficacy of the contractile strength of the heart (**FS**) and its haemodynamic characteristics (**EF**).

Mean value, standard deviation (SD), range and coefficient of variation (CV%) of all echocardiographic parameters were calculated .

## Results

The goats in this study had no history or evidence of cardiac dysfunction. No abnormalities were detected on clinical examination of the cardiothoracic systems of any of the animal and no murmurs or arrhythmia were detected by cardiac auscultation. On clinical evaluation, mean rectal temperature was  $38.2 \pm 0.6$  °C (reference range; 38.0-39.5 °C), mean heart rate was  $75 \pm 8$  bpm (reference range; 70–90 bpm) and mean respiratory rate of  $25 \pm 4$  bpm (reference range; 20–40 bpm).and the result in this study are divided into two parts. The first included studying the real time two-dimensional and M-mode echocardiographic examination which aimed to identify the standard echocardiographic imaging planes at short and long axis. The second division was aimed to take the normal echocardiographic dimensions.

### Part 1

#### Two- Dimensional (2D)echocardiographic examination

##### ***1- Right Parasternal long-Axis left ventricular outflow View.***

This view can visualized at 4<sup>th</sup> RICS (right inter costal space) and the transducer rotate bet 0°to30°caudally,in this view the left side of the heart, ventricle, atrium, left ventricular outflow and the aortic root were well visualized, with part of the right side and interventricular septum (Fig. 1).

##### ***2- Right Parasternal long-Axis four chamber View.***

This view can visualized at 4<sup>th</sup> RICS (right inter costals space) cranially. In this view, the aortic root disappear and the left atrium appear larger than in long-axis left ventricular outflow view and the interatrial septum appears in this view. The mitral and tricuspid valve is well visualized in this view (Fig. 2).

##### ***3-Right Parasternal Short-Axis Views.***

This views can visualized at 4<sup>th</sup> RICS (right inter costals space) 2 cm above elbow and the transducer rotate indifferent angles between 0°to90°perpendicularly on ICS (intercostal space).

##### ***A-Papillary muscles view***

The papillary muscles are seen protruding into the left ventricular chamber at 5 o'clock and 9o'clock positions, with the slim right ventricle around the left (Fig. 3a).

### ***B- Chordae tendinea view***

The chordae tendinea arise from papillary muscle and appeared as thin filaments swim in the left ventricular lumen. (Fig. 3b).

### ***C- Mitral valve view.***

This appeared oval shape within the left ventricular chamber and called mouth of fish during diastole (Fig. 3c).

### ***D-The heart base with aorta view.***

The aorta appeared in the central of image and the three aortic cusps appeared in this view and called (Mercedes sign).The left atrium and aorta appeared close in size in this plane (Fig. 3d).

### ***E- The heart base with pulmonary artery view***

The pulmonary artery appeared encircled around the aorta (Fig. 3e).

### ***4- Left Parasternal long-Axis four chamber View.***

This view can visualized at 4 RICS (left inter costals space) and the transducer rotate bet  $0^{\circ}$  to  $20^{\circ}$  craniodorsally. In this view, four chambers appear and the interatrial septum appears in this view. The mitral and tricuspid valve is well visualized in this view (Fig. 4).

### ***5- Left parasternal short axis view of the left ventricle view.***

This view can visualized at 4 RICS perpendicularly on ICS.

In which the right ventricular chamber and right ventricular wall were completely visualized and the left ventricular chamber appeared at the top of the image (Fig. 5).

## **M-Mode Echocardiographic Examination.**

This views can visualized at 4<sup>th</sup> RICS (right inter costals space) 2 cm above elbow and the transducer rotate indifferent angles between  $0^{\circ}$  to  $90^{\circ}$  perpendicularly on ICS (intercostal space).

### **1- Left ventricle.**

The interventricular septum appeared at the top of the image, followed by the left ventricular chamber and the left ventricular free wall at the bottom of the image. The pericardium appeared as a bright line just below the left ventricular free wall .the right ventricular wall could not be clear on M-mode images. The septum and left ventricular wall move away from each other during diastole and they move to each other during systole (Fig. 6).

## **2- Mitral valve**

The mitral valve motion appears as M-shape with two peaks. First peak is E-point which represents the motion of anterior mitral valve toward the interventricular septum during rapid ventricular filling phase of diastole. The second peak is A peak which occurs at the end of diastole due to left atrium contraction, (Fig. 7).

## **3- Aortic root.**

The right atrium was seen at the top of image, followed by the anterior and posterior aortic walls, which move parallel to each other. The aortic valve appeared as line in the center of the aorta (Fig. 8).

## **Measurement of cardiac dimensions.**

Left ventricular diameter in systole (LVs) and diastole (LVd) Right ventricular diameter in systole (RVs) and diastole (RVd), Left ventricular wall thickness in systole (LVWs) and diastole (LVWd) right ventricular wall thickness in systole (RVWs) and diastole (RVWd), interventricular septal thickness in systole (IVSs) and diastole (IVSd) and aorta in systole (Aos) and diastole (Aod) were measured from five consecutive cardiac cycles and averaged to take the mean values in both short and long axis views during systole and diastole in each goat to neglect the effect of respiration. All measured data were statically analyzed to take the mean values and standard deviations as in table (Table 1).

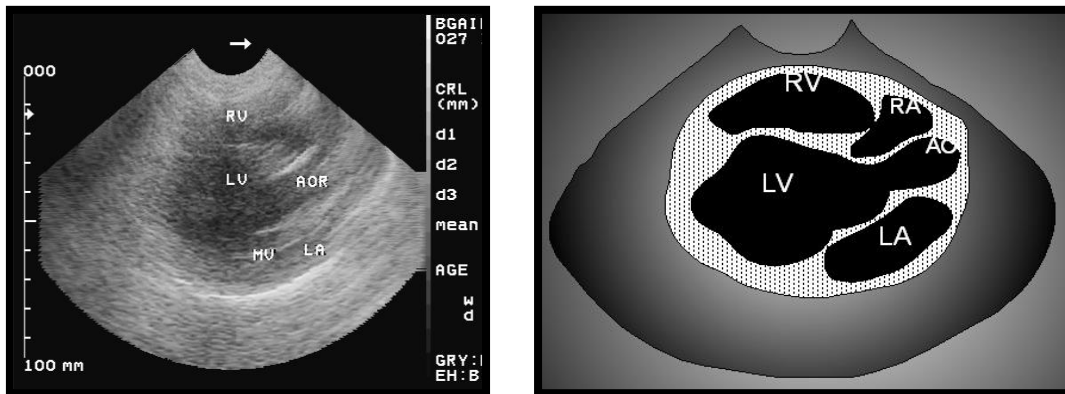


Fig. (1). Echocardiographic and schematic representation of right Parasternal long-axis left ventricular outflow view of the heart, the transducer at 4<sup>th</sup> RICS (right inter costal space) and the transducer rotate bet 0° to 30° caudally by 4MHz probe. LV= left ventricle, LA=left atrium, RV=right ventricle, RA= Right atrium and AO=aorta root.

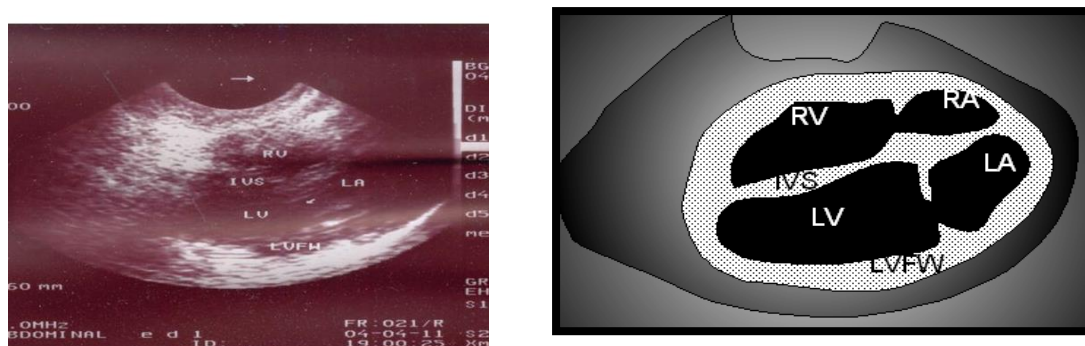


Fig.(2) Echocardiographic and schematic representation of right Parasternal long-axis four chambers of the heart, the transducer at 4<sup>th</sup> RICS (right inter costals space) cranially by 4MHz probe. LV= left ventricle, LA=left atrium, RV=right ventricle, RA=Right atrium, IVS=Interventricular septum and LVFW=Left ventricular free wall.

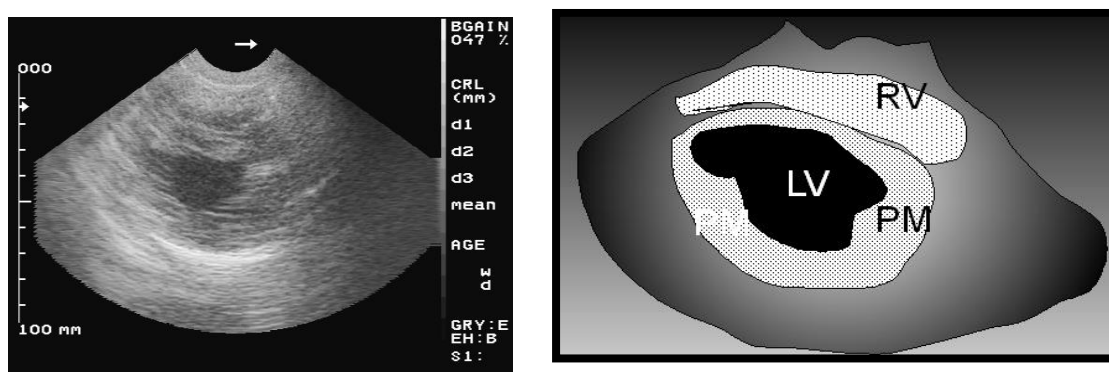


Fig.(3a). Echocardiographic and schematic representation of right parasternal short axis view at the level of papillary muscle. This 2-d cross sectional of the heart in which the right ventricle appeared crescent shape at the top of the image and circular shape of the left ventricle was seen below by 4MHz probe. RV=right ventricle, LV=left ventricle and PM =papillary muscle.



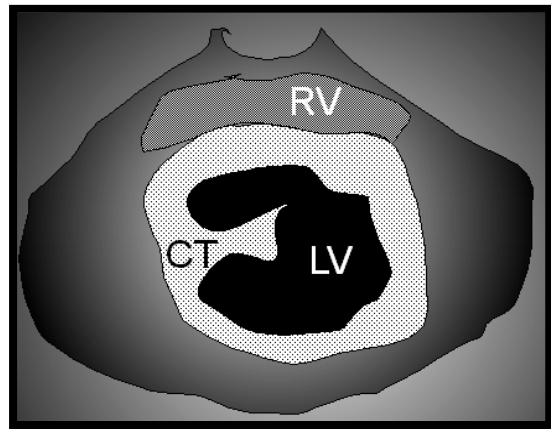
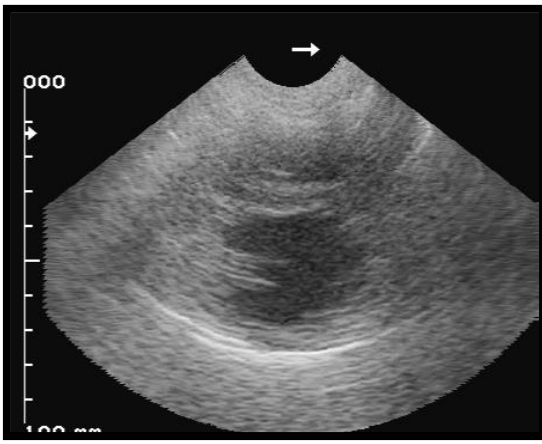


Fig.(3b). Echocardiographic and schematic representation of right parasternal short axis view at the level of chordae tendineae. slight movement of the transducer toward the base of the heart shows chordae tendineae at their attachment points on papillary muscle which appear as thin filaments swim in left ventricular lumen by 4MHz probe. RV=right ventricle, LV=left ventricle and CT = chordae tendinea.

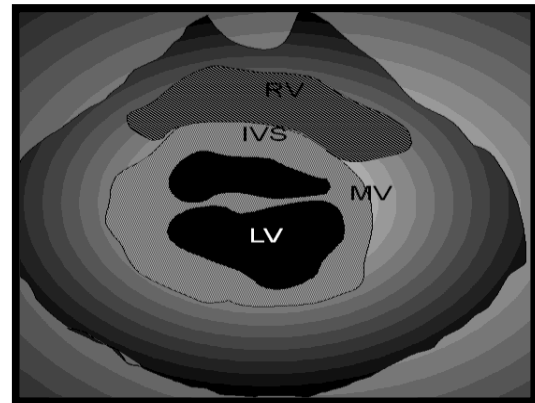
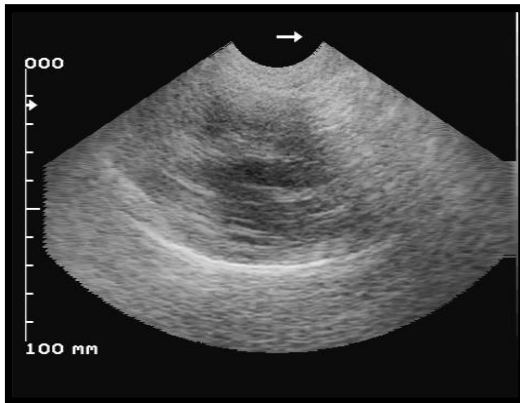


Fig.(3c). Echocardiographic and schematic representation of right parasternal short axis view at the level of mitral valve. The leaflets of mitral valve appeared oval shaped and called fish mouth during diastole by 4MHz probe. RV=right ventricle, LV=left ventricle, IVS= interventricular septum and V=mitral valve.

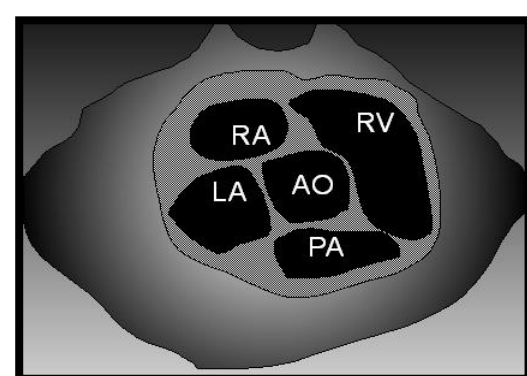
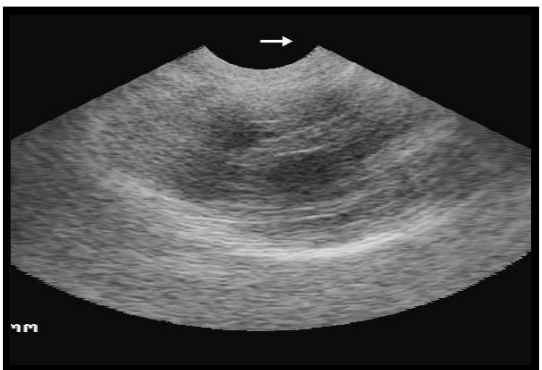


Fig.(3d). Echocardiographic and schematic representation of right parasternal short axis view of heart base with aorta. The aorta was seen as circle in the middle of image by 4MHz probe. RV=right ventricle, LA=left atrium, RA= right atrium , PA = pulmonary artery and AO=aorta root.

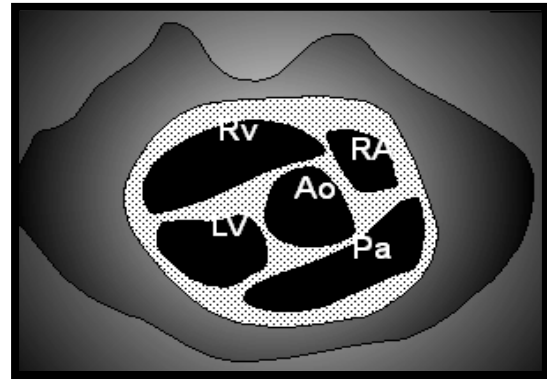
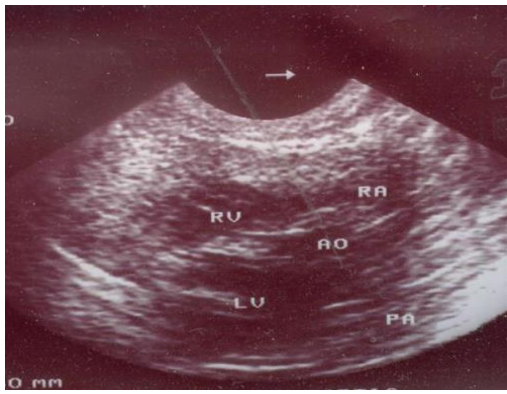


Fig.(3e). Echocardiographic and schematic representation of right Parasternal short axis view of heart base with pulmonary artery by 4MHz probe. LV= Left Ventricle , PA=Pulmonary Artery, RV=Right Ventricle, RA= Right Atrium and AO=Aorta Root.

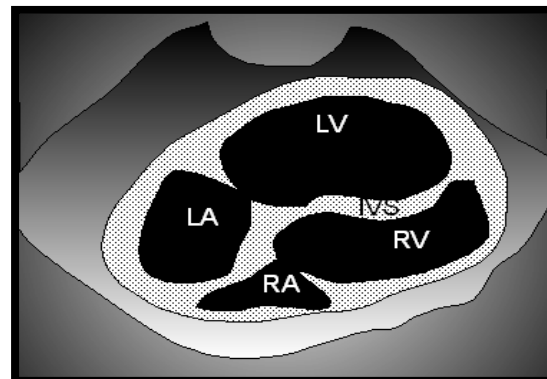


Fig.(4). Echocardiographic and schematic representation of left Parasternal long-axis four chambers of the heart. The transducer at 4 RICS (left inter costals space) and the transducer rotate bet 0°to20° craniodorsally by 4MHz probe. LV= left ventricle, LA=left atrium, RV=right ventricle, RA= Right atrium and IVS=Interventricular septum.

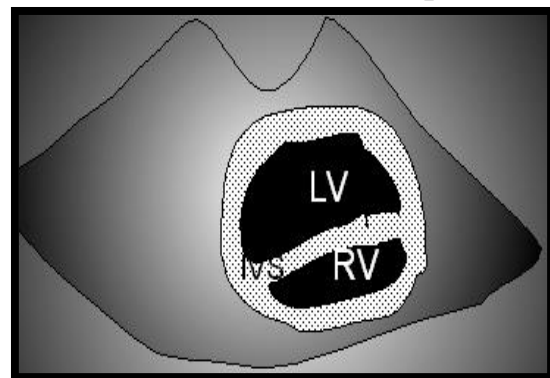


Fig.(5). Echocardiographic and schematic representation of left parasternal short- axis view of left ventricle. The left ventricle appear at the top of the image. The transducer at 4 RICS perpendicularly on ICS by 4MHz probe. LV=left ventricle, RV=right ventricle and IVS= Interventricular septum.



**Table 1 Internal echocardiographic measurements in healthy adult Egyptian zarabi goats. (N=11)**

<b>Variable</b>	<b>Mean</b>	<b>SD</b>	<b>CV%</b>
<b>LVs (cm)</b>	2.413	0.21	8.7
<b>LVd (cm)</b>	3.211	0.32	9.9
<b>RVs (cm)</b>	2.112	0.23	10.8
<b>RVd (cm)</b>	2.24	0.22	9.8
<b>LVWs(cm)</b>	0.941	0.121	12.8
<b>LVWd(cm)</b>	0.721	0.06	8.3
<b>RVWs(cm)</b>	0.811	0.09	11
<b>RVWd(cm)</b>	0.699	0.10	14.3
<b>IVSs(cm)</b>	1.002	0.11	10.9
<b>IVSd(cm)</b>	0.881	0.12	13.6
<b>Aos(cm)</b>	1.23	0.17	13.8
<b>Aod(cm)</b>	1.24	0.18	6.8
<b>FS%</b>	24.5	2.71	11.06
<b>EF%</b>	57.5	4.1	14.4

N, number of the goats; **SD**, standard deviation; **CV**, coefficient of variation; **RV**, right ventricular diameter; **LV**, left ventricular diameter; **RVW**, right ventricular wall thickness; **IVS**, interventricular septal thickness; **LVW**, left ventricular wall thickness; **AO**, aortic diameter; **D**, diastole; **S**, systole. **FS** = fractional shortening. **EF** = ejection fraction.

## **Discussion**

Echocardiography allows investigation of the morphology and function of cardiac structures and measurement of cardiac dimensions. In cattle, dogs and horses, measurement of cardiac chamber dimensions is considered one of the most important tools for assessing heart disease severity and prognosis **Hallowell et al, (2007)**. In the adult zarabi goats, there is a lack of data regarding normal echocardiographic patterns and internal cardiac dimensions hinders the progress in the diagnosis of goat cardiovascular diseases. Knowledge of the normal appearance and cardiac dimensions should improve identification, quantification and assessment of cardiac disease and may allow an earlier diagnosis and more prompt intervention when facing to abnormal echocardiographic findings. **Leroux, et al.,(2012)**.

During echocardiography, a phased array transducer is preferred, if available. However, a large sectorial or even linear probe is generally sufficient. In the present study, although the echocardiographic

examination was carried out using a 3.5-MHz sectorial transducer, which was the only available probe, it was effective in performing all the scanning views of the heart **Steininger, et al.,(2011)**. In this study, some differences in transducer placement were noted compared to other ruminant studies **Hallowell et al, (2007)**. The right parasternal long-axis four-chamber view was obtained with the transducer placed in the 5th ICS. In addition, the LVOT on the right 4<sup>th</sup> ICS was orientated differently from other bovine studies **Hallowell et al, (2007)** and **Hallowell et al, (2012)**. The LVOT in most of the goats could be visualized together with the four-chamber view at the right 4th ICS. And right parasternal short axis views can be visualized easil from the right side at 4 ICS and the probe in a perpendicular axis on the rib. **Steininger, et al.,(2011)**. Left Parasternal long-Axis four chamber View and Left parasternal short axis view of the left ventricle view were completely visualized at 4ICS at the left side **Hallowell et al, (2007)** and **Olsson et al., (2001)**.By M-mode the left ventricle view can visualized at 4<sup>th</sup> RICS (right inter costals space) 2 cm above elbow and mitral and aortic view can visualized from 4<sup>th</sup> RICS but the transducer rotate bet 0°to30° perpendicularly on ICS. **Hallowell et al, (2012)**.

Internal cardiac measurements have been shown to be extremely valuable in dogs, cattle and horses **Belanger, (2010), Boon, (1998)**. The dimensions of left ventricle during systole and diastole were significantly ( $P>0.01$ ,  $P>0.001$ ) greater than those of right ventricle during systole and diastole respectively. The size of ventricles was significantly greater than diastole(table 1).The inerventricular septum and left and right ventricular free wall were significantly greater in systole than diastole ( $P>0.01$ ,  $P>0.001$ ) respectively.diameter of the aorta did not differ significantly from systole to diastole. (**El-khodery et al., 2010**) and **Hallowell et al, (2012)**.

In the present study, Coefficient of variation (CV%) of examined variables varied from 6.8-14.4 . In our opinion, the value is considered satisfactory for this result, because the variations in animal weight and age may give larger range of variable's dimensions. (**El-khodery et al., 2010**) and **Hallowell et al, (2012)**. It assumes normal ventricular morphology, afterload, preload and ventricular contractility **Slater, and Herrtage, (1995)**.

**Conclusions:** This study showed that it is possible to obtain good-quality echocardiograms in adult goats and provide normal goats dimensions.Moreover This study could be used as a reference for further studies concerning.

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