



UNIVERSITI PUTRA MALAYSIA

***ULTRASONOGRAPHY IMAGING STUDY OF THORACIC ORGAN IN
GOAT***

NURUL SYAHIRAH HUSNA SULAIMAN

**Ip
FPV 2016 14**

**ULTRASONOGRAPHY IMAGING STUDY OF
THORACIC ORGAN IN GOAT**

NURUL SYAHIRAH HUSNA SULAIMAN

FACULTY OF VETERINARY MEDICINE

UNIVERSITI PUTRA MALAYSIA

SERDANG, SELANGOR

2016

**ULTRASONOGRAPHY IMAGING STUDY OF
THORACIC ORGAN IN GOAT**

NURUL SYAHIRAH HUSNA SULAIMAN

A project paper submitted to the

Faculty of Veterinary Medicine, Universiti Putra Malaysia

In partial fulfilment of the requirement for the

DEGREE OF DOCTOR OF VETERINARY MEDICINE

Universiti Putra Malaysia

Serdang, Selangor Darul Ehsan

MARCH, 2016

It is hereby certified that I have read this project paper entitled “Ultrasonography Imaging Study of Thoracic Organ in Goat”, by Nurul Syahirah Husna Sulaiman. In our opinion, it is satisfactory in terms of scope, quality and presentation as partial fulfilment of the requirement for the course VPD 4999- Project.

PROF. DR. ABD WAHID HARON
DVM (UPM), PHD (DUBLIN)

Lecturer,
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Supervisor)

DR. SITI ZUBAIDAH RAMANOON
DVM (UPM), M.S. (Guelph)

Lecturer,
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Co-supervisor)

DEDICATIONS

To the love of my life.....

Abah, Ummi and Along,

Ummi, for loving me unconditionally and be a good friend to me

Abah, for always support and motivate me.

Along, for be the best cooker ever

Love all of you.

ACKNOWLEDGEMENTS

First of all, I would like to express my greatest gratitude to everyone that directly or indirectly involved in making the objectives of this paper accomplished. Most sincere appreciation and thanks to my supervisor, Prof. Dr. Abd Wahid Haron for all his guidance, motivation, and encouragement throughout these 6 weeks of final year project period. I would also like to take this opportunity to thank Dr. Siti Zubaidah Ramanoon for her keenness to help and support me in doing this project. My heartily thankful also goes to En. Fahmi and Mr. Yap Keng Chee for helping me in taking and bringing the ultrasound machine and for your moral support, Kak Zie and Boey for accompany me throughout this project, Dr. Mark for his motivation and Dr. Khor for her suggestion and advice. My special thanks for Kak Shidah, Atty and Farah for the support. Finally, I wish to deliver my special thanks to my family.

Thank you,

NURUL SYAHIRAH HUSNA SULAIMAN

ABBREVIATION

AO= aorta

IAS= interatrial septum

IVS= interventricular septum

LA= left atrium

LC= left coronary

LV= left ventricle

LVW= left ventricular wall

MV= mitral valve

NC= noncoronary

P= pleural line

PM= papillary muscle

PV= pulmonary valve

RA= right atrium

RC= right coronary

Rev= reverberation

RV= right ventricle

CONTENTS

	Page
TITLE	i
CERTIFICATION	ii
DEDICATION	iii
ACKNOWLEDGEMENTS	iv
ABBREVIATION	v
CONTENT	vi
LIST OF FIGURES	ix
ABSTRAK	x
ABSTRACT	xii
1.0 INTRODUCTION	1
2.0 LITERATURE REVIEW	2
2.1 Introduction	2
2.2 Transducer	2
2.3 Frequency	2
2.4 The heart of a goat	3

2.5 Non-cardiac thoracic ultrasound	3
2.6 Echocardiography	3
3.0 MATERIALS AND METHODS	5
3.1 Animals	5
3.2 Pre imaging preparation	5
3.3 Ultrasonography procedures	5
3.3.1 Examination of the heart	6
3.3.2 Examination of the pleura	6
4.0 RESULTS	9
4.1 Right Parasternal Long Axis Left Ventricular Outflow view	8
4.2 Right Parasternal Long Axis Four Chamber view	8
4.3 Right Parasternal Short Axis views	8
4.3.1 Papillary Muscle level	9
4.3.2 Mitral Valve level	10
4.3.3 The Heart Base with Aorta level	11
4.4 Left Parasternal Long Axis Four Chamber view	12
4.5 Left Parasternal Short Axis of Heart Base view	13
4.6 Lung	14

5.0	DISCUSSION	15
6.0	CONCLUSION AND RECOMMENDATIONS	17
7.0	REFERENCES	18



© COPYRIGHT UPM

LIST OF FIGURES

Figure 1: Transducer placement for the left parasternal long axis view	7
Figure 2: Transducer placement for the right parasternal short axis view	7
Figure 3: Right Parasternal Long Axis Left Ventricular Outflow view	8
Figure 4: Right Parasternal Long Axis Four Chamber view	9
Figure 5a: Right Parasternal Short Axis view with Papillary Muscle level	10
Figure 5b: Right Parasternal Short Axis with Mitral Valve level	11
Figure 5c: Right Parasternal Short Axis view with Aorta level	12
Figure 6: Left Parasternal Long Axis Four Chamber view	13
Figure 7: Left Parasternal Short Axis Heart Base with Aorta view	13
Figure 8: Lung ultrasound by using linear transducer	14
Figure 9: Lung ultrasound by using convex transducer	14

ABSTRAK

Abstrak daripada kertas kerja yang dikemukakan kepada Fakulti Perubatan Veterinar untuk memenuhi sebahagian daripada keperluan kursus VPD 4999 – Projek.

KAJIAN PENGIMEJAN ORGAN TORAKS MENGGUNAKAN KAEDAH ULTRASONOGRAFI DALAM KAMBING

oleh

Nurul Syahirah Husna Sulaiman

2016

Penyelia : Profesor Dr. Abd Wahid Haron

Penyelia bersama : Dr. Siti Zubaidah Ramanoon

Ultrasonografi adalah alat yang tidak invasif dan jarang digunakan dalam pemeriksaan organ toraks dalam kambing. Dalam kajian ini, organ toraks yang merupakan jantung dan paru-paru diperiksa dengan menggunakan teknik ultrasonografi untuk menggambarkan struktur dan lokasi anatomi organ. Bulu bagi lima kambing telah dicukur dari kawasan selepas tulang belikat sehingga tulang rusuk terakhir untuk kedua-dua toraks kiri dan kanan. Gel akustik diletak pada transduser. Pemeriksaan dilakukan di kedua-dua bahagian kiri dan kanan toraks dengan menggunakan 5 MHz transduser cembung dan linear. Dalam pemeriksaan jantung, lima jenis pengimejan diperolehi dari kanan dan dua dari sebelah kiri di kawasan ruang intercostal ke-4. Pengimejan ultrasonografi terhadap paru-paru

yang dilakukan di kawasan ruang intercostal ke 7 hingga 11 menunjukkan garis mendatar hyperechoic dengan gema artifak .Kesimpulannya, semua jenis pengimejan echocardiography boleh diperolehi dari ruang intercostal-4 lebih kurang 2 cm di atas olecranon dan paru-paru ultrasonografi adalah di antara 7 sehingga 11 ruang intercostal.

Kata kunci : Ultrasonografi, Kambing, Jantung, Paru-paru



ABSTRACT

An abstract of the project paper presented to the Faculty of Veterinary Medicine in partial fulfilment of the course VPD 4999- Final Year Project

**ULTRASONOGRAPHY IMAGING STUDY OF THORACIC ORGAN IN
GOAT**

by

Nurul Syahirah Husna Sulaiman**2016****Supervisor: Prof. Dr. Abd Wahid Haron****Co-supervisor : Dr. Siti Zubaidah Ramanoon**

Ultrasonography is a non-invasive tool that is less commonly used for thoracic examination in goat. In this study, the thoracic organ which is the heart and lung is examined by using the ultrasonography technique to describe the structure and the anatomical location of the organ. Five animals were clipped from area caudal to scapula until the last rib for both left and right thorax. Coupling gel was applied to the transducer. Examination was done for both left and right side of the thorax by using the 5 MHz convex and linear probe. In echocardiography, five imaging plane were obtained from the right and two from the left side of the 4th intercostal space. Lung ultrasound shows the hyperechoic horizontal line with reverberation artifact. In conclusion, all echocardiography imaging plane were obtain at the 4th intercostal space slightly 2 cm above the olecranon and lung ultrasound is at between the 7th until 11th intercostal space.

Keywords: Ultrasound, Goat, Heart, Lung

CHAPTER I

GENERAL INTRODUCTION

Ultrasonography of the thorax organs enables the evaluation of pleural surface of the lung and superficial lung parenchyma, heart and mediastinal region (Palgrave, 2015). Normal pleural surface which is in contact with aerated lung will appear as a uniformly hyperechoic line which moves in synch with respiration (Kimberly Palgrave). The normal lung should extend to the margin of the thoracic wall and appear as a highly echogenic line with reverberation artifact. Internal parenchyma of the lung cannot be assessed in normal animal due to air interface (Armburst, 2011). The mediastinum is difficult to image because it is surrounded by lung, which results in reflection of the ultrasound beam but cranial mediastinum can be imaged through the intercostal space (Armburst, 2011).

Ultrasonography of the heart is called an echocardiography. Echocardiography is a non-invasive method for assessment of the goat heart and it can provide a good to excellent technique and measurement reliability which can be obtained from echocardiographic dimensions and time indices (Hallowell *et al.*, 2012). The most technically challenging views to obtain were the short axis views of the mitral valves and aortic valves due to poor visualization due to hyperechogenicity of the pleural space and therefore specific species reference ranges in cardiac dimension is required (Hallowell *et al.*, 2012). This study was conducted with the objective to describe the anatomical structure and location of the thoracic organ of goat using ultrasonography imaging technique.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Ultrasonography imaging in small ruminant is mainly use for examination of female reproductive tract as a tool for pregnancy diagnosis and it is less commonly to be used for examination of abdominal and thoracic organs.

2.2 Transducer

Common types of transducer or also known as probe are linear, convex and phased array type (Kircher, 2011). The type of transducer used is depending on the structure to be evaluated and the distance of it to the transducer (Hallowel & Potter, 2008). In performing echocardiography, phased array probe is most suitable (Hallowell & Potter, 2012; Tharwat *et al.* 2012) due to its small footprint which helps in overcoming the limitation of the small access windows between the rib and interferences by the aerated lung (Brown & Gaillot, 2008). For lung and pleura examination, linear transducer (Flock, 2003), sector or small footprint transducer can be used (Hecht, 2008).

2.3 Frequency

Frequency of the transducer will determine the depth of penetration and image resolution (Boon, 2011). Low frequency produces a better depth penetration meanwhile high frequency give a better resolution image (Kircher, 2011). The frequency of the probe used will be based on certain factors which are the size of the animal and location of the organ to be examined. Frequency for lung examination

will depend on the location of the lesion with superficial lesion may need a higher frequency (7.5 or 10.0MHz) (Hecht, 2008).

2.4 The Heart of goat

The location of the heart according to (Smith & Sherman, 2009) is at third to sixth intercostal space based on radiograph of dorsoventral view. According to (Leroux *et al.*, 2012) goat heart is comparable to the human.

2.5 Non-cardiac thoracic ultrasound

Thoracic ultrasound allows the examination of the pleural surface and superficial parenchyma (Palgrave, 2015). Thoracic ultrasonography for lung was usually done from 7th to 11th intercostal space dorsoventrally parallel to the ribs (Flock, 2003). Ultrasonography has been used as a tool to diagnose lung disease and traumatic reticuloperitonitis in ruminant by Flock (2003). Three approaches of the lung ultrasonography can be conducted based on the structures to be evaluated which are the intercostal approach, thoracic inlet approach and subcostal approach (Hecht, 2008). Thoracic ultrasonography allows examination of mass and effusion (Seiler, 2011) and abnormality mostly obvious from the cranial and above all the cranioventral lung areas (Flock, 2003).

2.6 Echocardiography

Echocardiography is an important diagnostic tool for examination of the cardiac morphology and measurement of the cardiac dimension (Tharwat *et al.*, 2012). Three type of echocardiography examination are Time-motion mode (M-mode) which important for measurement of the cardiac dimension, B-mode for

cardiac structural and Doppler for evaluation of the cardiac blood flow. M-mode images are obtain from three levels which are the left ventricle, mitral valve and aortic root in both long axis and short axis planes (Boon, 2011). Usually, several views will be taken during echocardiography. The three B-mode views used by Hallowell & Potter (2012) for echocardiography in goat are right parasternal long axis, right short axis view and left parasternal view



CHAPTER III

MATERIALS AND METHODS

3.1 Animals

Five apparently healthy adult female age 3-4 years old goats with uniform body condition score weighing $29.5\text{kg} \pm 3.3\text{kg}$ from Taman Pertanian Universiti, Universiti Putra Malaysia were selected for the study. The goats were rear intensively with cut and carry grass and pellet twice a week and water change for once a day. The goat housing is high raised slatted floor and located at the hilly area. Physical examination was conducted and all selected animals showed no audible murmur during auscultation of the heart.

3.2 Pre imaging preparation

The examination area in all animals were shaved with clipper extending from caudal to the scapula until the last rib, and from the transverse process of thoracic vertebrae until the level of the elbow on both sides. Fine shaving with shaver was also done to eliminate the remaining hair for optimum contact to the animal skin during scanning. The skin was clean by using diluted hibiscrub and wipe to dry before applying the coupling gel. All animals were unsedated and physically restrained during examination.

3.3 Ultrasonography procedures

Ultrasound examination was performed by using Sonoscape A6V scanner attached to linear and convex transducer. All images were obtained by using the B-mode ultrasonography with static images was saved into a disk. The images obtained was

describe based on the structure visualize and location of the transducer placement on the animal thorax.

3.3.1 Examination of the heart

Convex transducer with frequency of 5MHz was used for examination of the heart. The depth and gain was adjusted according to the image quality. Transducer was placed at 3rd, 4th and 5th intercostal space 2cm above the elbow for left and right sides. The transducer was placed perpendicularly to the thoracic wall with the transducer marker facing towards the spine. The transducer was rotated clockwise and counterclockwise to obtain the required imaging plane of the heart. The right parasternal long axis view image was done with the transducer at right 4th ICS at 0° rotation which the transducer marking facing towards the spine for four chamber view and 30° for left ventricular outflow tract view (Figure 1). In right parasternal short axis view (Figure 2), the transducer was rotated clockwise towards 90°.

3.3.2 Examination of the pleura

Linear and convex transducer with frequency of 5MHz was used for examination of lung and pleura region. Probe was placed from 7th to 11th intercostal space dorsoventrally parallel and perpendicular to the ribs for both right and left sides.

Figure 1: Transducer placement for the left parasternal long axis view. The orange circle is showing the transducer marker. The transducer was at 30° rotation. In the schematic diagram at top left side of the image, the green dotted line is the rotation of the transducer at 0° for the four chamber view and the blue dotted line is the rotation of the transducer at 30° for left ventricular outflow view.

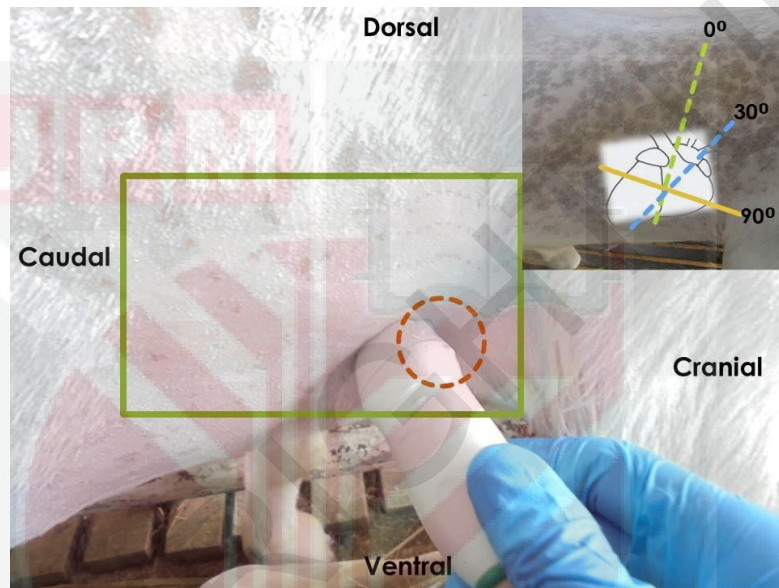
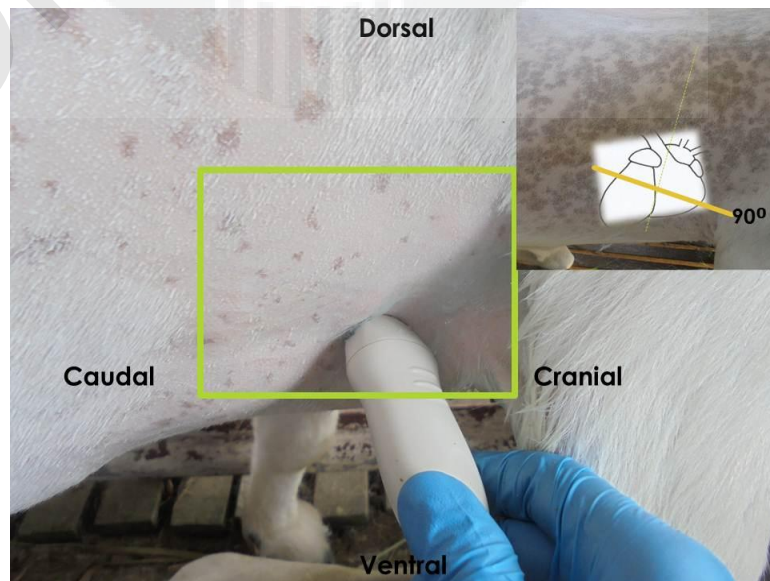


Figure 2: Transducer placement for the right parasternal short axis view. The transducer marker is facing cranioventrally at 4 o'clock position. In the schematic diagram at top left side of the image, the yellow line is the rotation of the transducer at 90°.



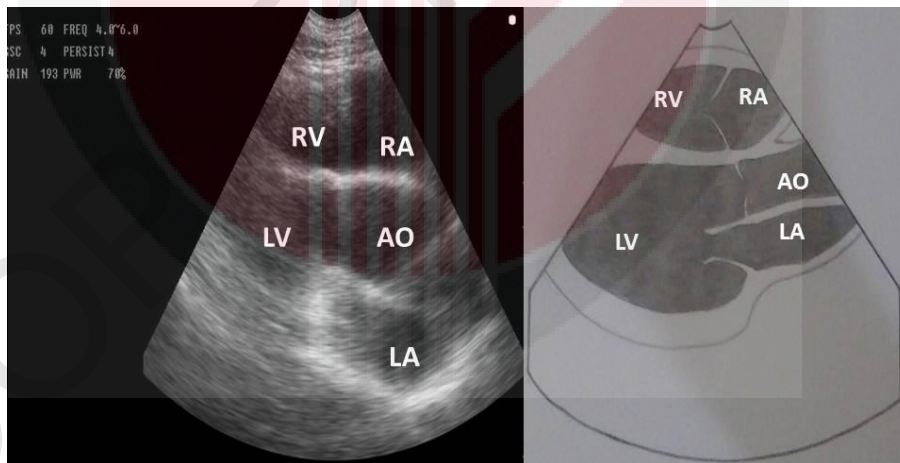
CHAPTER IV

RESULTS

4.1 Right Parasternal Long Axis Left Ventricular Outflow view (Figure 3).

This view can be visualized at 4th right ICS (intercostal space) with the transducer marker facing dorsocranially at 1 o'clock position or rotated at 30°. In this view, right ventricle and right atrium is at the top of the sector with the right ventricle on the left side and right atrium on the right side of the sector. Below the right atrium is the aorta. At bottom left of the sector is the left ventricle and left atrium is visualized below the aorta on the right side of the sector.

Figure 3: Right Parasternal Long Axis Left Ventricular Outflow view. AO= aorta, LA= left atrium, LV= left ventricle, RA= right atrium, RV= right ventricle.

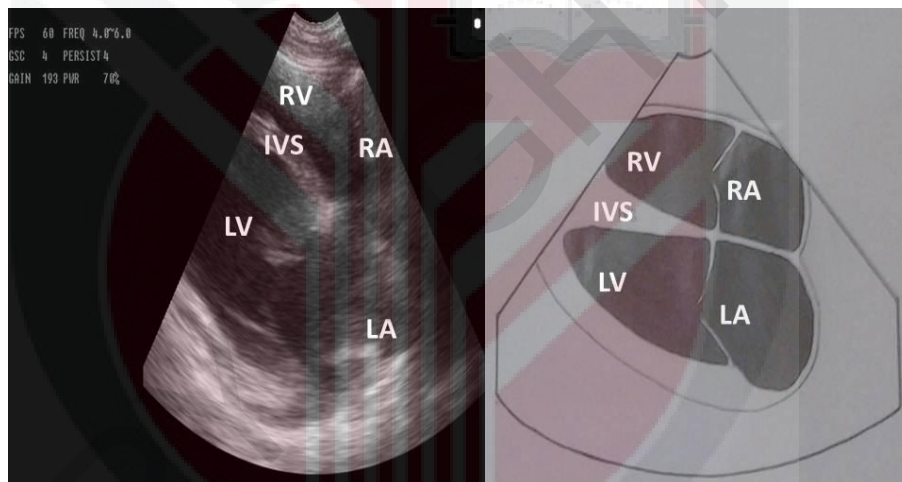


4.2 Right Parasternal Long Axis Four Chamber view (Figure 4)

This view can be visualized at 4th right ICS with the transducer marker facing dorsally at 12 o'clock position which is at 0°. This view is called as four chamber view as we can see all four chambers in the sector with right ventricle and right

atrium is at the top of the sector which right ventricle at the left and right atrium at the right side of the sector. Below the right ventricle is the interventricular septum (IVS) that is continuous with interatrial septum (IAS) that is separating the right atrium and left atrium. Junction between the IVS and IAS rise the tricuspid valve on the top and mitral valve below. Left ventricle and left atrium at bottom of the sector with left ventricle at left and left atrium at the right side of the sector.

Figure 4: Right Parasternal Long Axis Four Chamber view. IVS= interventricular septum, LA= left atrium, LV= left ventricle, RA, right atrium, RV= right ventricle



4.3 Right Parasternal Short Axis views

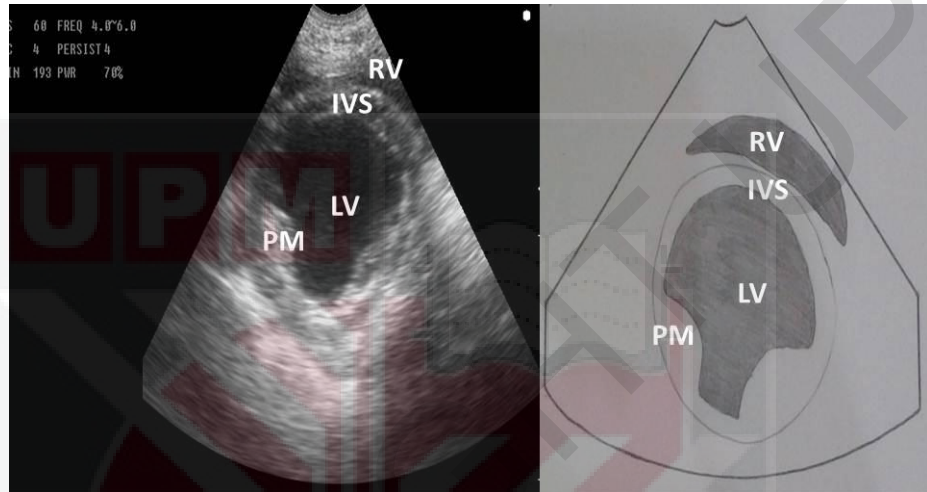
This view can be visualized at 4th right ICS with the transducer marker facing at 4 o'clock position which it is rotated from 0^o to 90^o.

4.3.1 Papillary Muscle level (Figure 5a)

Right ventricle is at the top of the sector is appear like a crescent shape. Below the right ventricle is the left ventricle that is circular in shape. Within the left ventricular chamber is the papillary muscle that is symmetrical in shape both left and right. Between right ventricle and left ventricle is the interventricular septum. The image

of the papillary muscle protruding from the left ventricle chamber appears as mushroom-like shape.

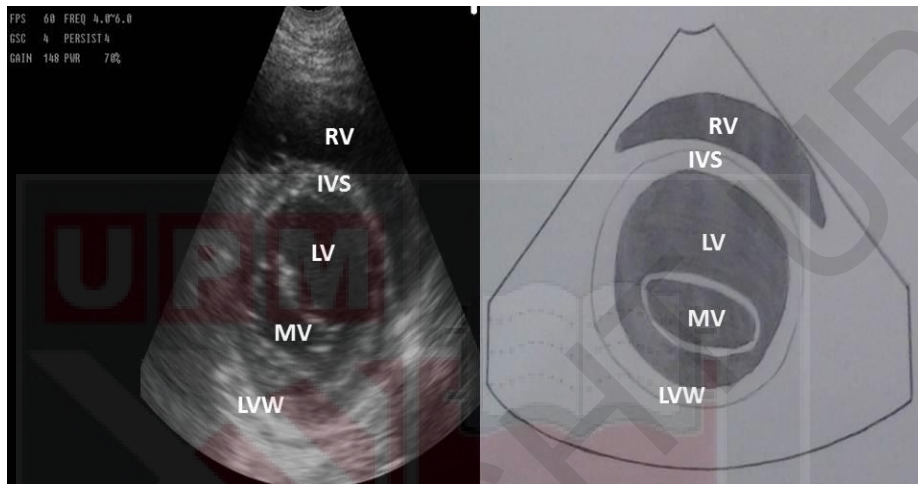
Figure 5a: Right Parasternal Short Axis view with Papillary Muscle level. IVS= interventricular septum, LV= left ventricle, PM= papillary muscle, RV right ventricle



4.3.2 Mitral Valve level (Figure 5b)

Mitral valve is located just above the papillary muscle. The transducer was facing cranially than the papillary muscle level. Right ventricle is at the top of the sector which appear as crescent-like shape. Below the right ventricle is the left ventricle that is circular in shape. Within the left ventricle is mitral valve that is appear as oval shape and it is appear as fish mouth during diastole.

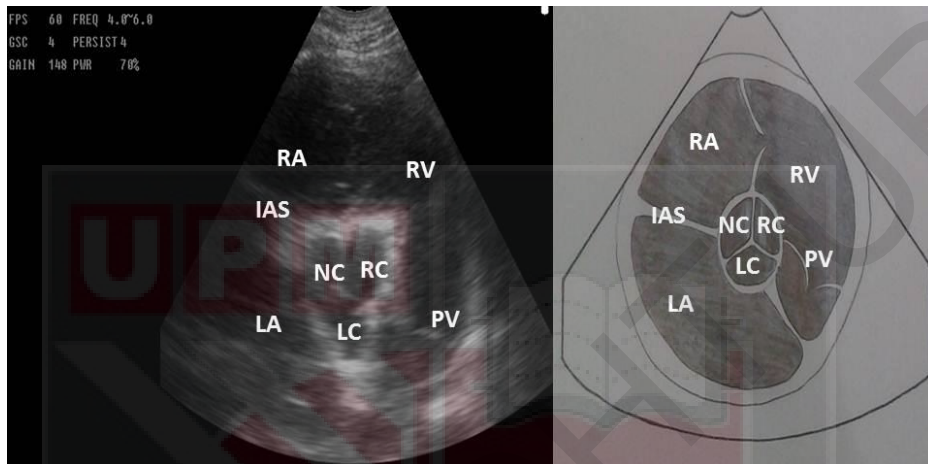
Figure 5b: Right Parasternal Short Axis with Mitral Valve level. IVS= interventricular septum, LV= left ventricle, LVW= left ventricular wall, MV= mitral valve, RV= right ventricle



4.3.3 The Heart Base with Aorta level (Figure 5c)

Aorta is seen as a clover shape in the middle of the sector image. All the valve cusps can be seen clearly. The cusps that is at the junction of the interatrial septum known as noncoronary cusp. The cusp at the right side which is near the right ventricle is known as right coronary cusp. The cusp below the other two cusps and above the left atrium is known as left coronary cusp. The right atrium is at the left top of the sector image. The right ventricle is at top of the image extending towards the right side of the sector. Pulmonary valve is seen at the bottom right of the sector and left atrium at the bottom left of the sector image.

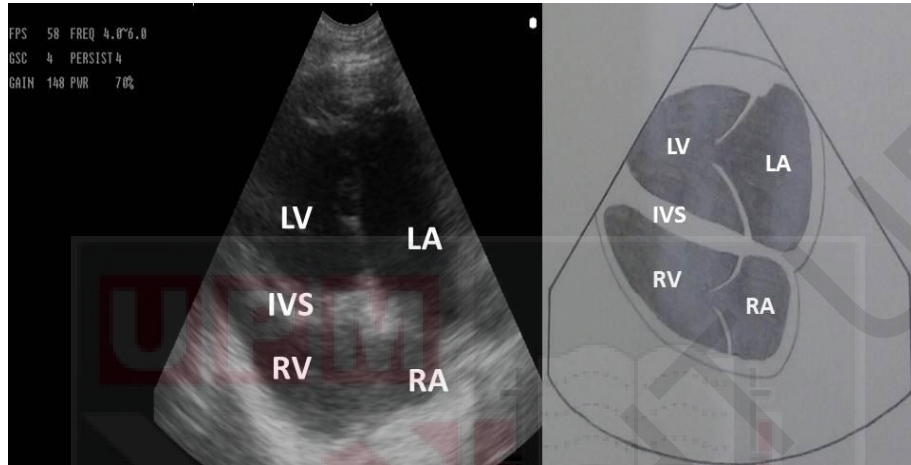
Figure 5c: Right Parasternal Short Axis view with Aorta level. IAS= interatrial septum, LA= left atrium, LC= left coronary cusp, NC= noncoronary cusp, PV= pulmonary valve, RA= right atrium, RV= right ventricle



4.4 Left Parasternal Long Axis Four Chamber view (Figure 6)

This image can be visualized at 4th left ICS (intercostal space) with the transducer marker facing 12 to 1 o'clock or between 0° to 30°. All four chambers can be visualized in the sector with the left ventricle and left atrium at top of the sector and right ventricle and right atrium at the bottom of the sector. IVS can be seen between the left ventricle and right ventricle. IVS and IAS is the continuous structure which at the junction is the mitral valve located at the top and tricuspid valve located at the bottom of the junction.

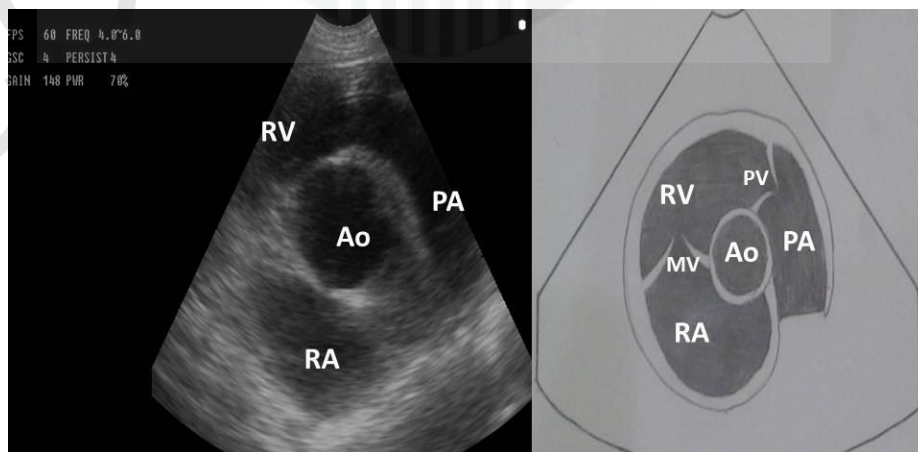
Figure 6: Left Parasternal Long Axis Four Chamber view. IVS= interventricular septum, LA=left atrium, LV= left ventricle, RA= right atrium, RV= right ventricle



4.5 Left Parasternal Short Axis of Heart Base view (Figure 7)

This image can be visualized at 4th left ICS with the transducer facing 4 o'clock position and fanning cranial and caudal. The aorta can be visualized at the center of the sector which is round in shape. Below the aorta is the right atrium with right ventricle is at the top and pulmonary artery at the right of the aorta.

Figure 7: Left Parasternal Short Axis Heart Base with Aorta view. Ao= aorta, PA= pulmonary artery, RA= right atrium, RV= right ventricle.



4.6 Lung (Figure 8 & 9)

This organ is visualized within 7th to 11th ICS for both right and left side of the thorax. The top of the image is the thoracic wall, and below is the pleural line characterized by thick white echogenic line. The artifact of reverberation effect can be seen below the pleural line which appears as hyperechoic horizontal line.

Figure 8: Lung ultrasound by using linear transducer. P= pleural line, Rev= reverberation artifact

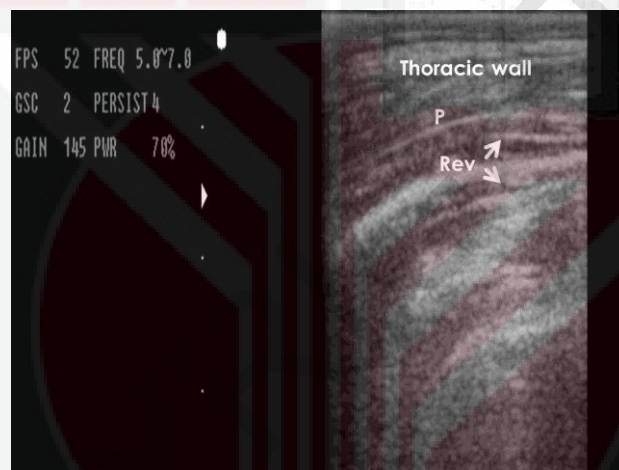
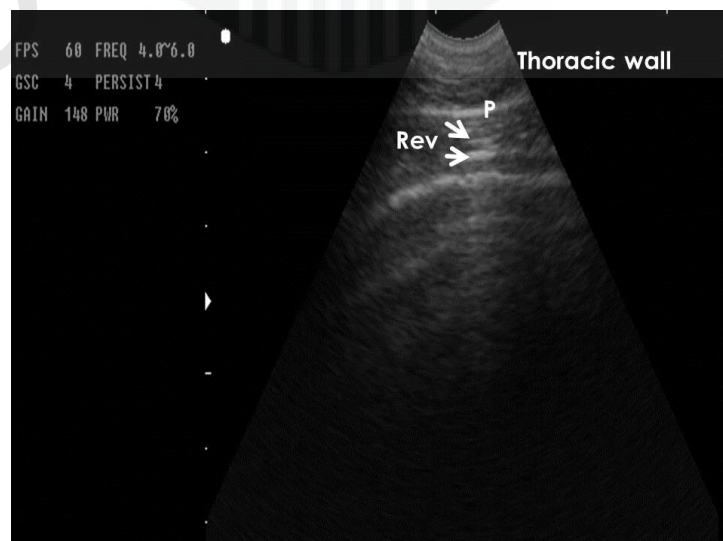


Figure 9: Lung ultrasound by using convex transducer. P= pleural line, Rev= reverberation artifact



CHAPTER V

DISCUSSION

Most imaging plane of heart which are the right parasternal long axis for left ventricular outflow tract and four chamber view and right parasternal short axis of left ventricle, mitral valve, and heart base can be seen within 4th right intercostal space as mention in previous study done by Hallowell & Potter (2012). The left parasternal short axis with heart base view is obtained in this study which is not documented in other ultrasonography study in goat done by the Tharwat *et al.* (2012) and this image is referred based on the horse echocardiography by Boon (2011). Labelling of the echocardiography images in this study was compared with the horse and small animal echocardiography images. The image obtained from this study is by using the convex probe which it result in a good image of the heart structure which in the previous study, most transducer that is recommended to be use is the phased array type due to its small footprint which can overcome the small acoustic window of the intercostal space (Hallowel & Potter, 2008). In this study when the transducer is place on the right side of the thorax, the right chamber of the heart will be on the top of the sector image and vice versa which supported by Boon (2011). There is lack of documented images for the heart structure in goat, thus this study can provide the reference images. Besides that, the placement of the transducer for getting the specific echocardiography imaging plane was similar with other previous study, hence this technique can be used as a standard to obtain the M-mode ultrasonography as repeatability is important as mention by (Hallowell & Potter, 2012)

For lung ultrasonography, linear probe appear to show more better and clear image as compared to the convex probe. Lung structure can be seen starting from the 7th until 11th intercostal space dorsocranially as there is presence of liver structure from 7th to 12th ICS ventrocaudally. Pleural line that is characterized by horizontal hyperechoic line just below the chest wall is made up by the visceral and parietal pleural surface (Khosla, 2012). Reverberation artifact rises below to the pleural line seen from the lung ultrasonography is form due to lung periphery is fully aerated and may be consider normal (Lichtenstein *et al.*,2009) with the present of lung sliding (Mathew & Kory, 2010; Khosla, 2012). Lung sliding is the sliding between the parietal and visceral surface that is characterized by the moving of the white line to and fro synchronous with the respiration (Khosla, 2012). Examination of lung by ultrasound can be done less than 15 minutes for both left and right side. This quick diagnostic tool can help in diagnosing animal with lung abscess or if there is presence of mass within the thorax.

CHAPTER VI

CONCLUSION AND RECOMMENDATIONS

As a conclusion the location for the transducer placement to visualize the heart is at 4th ICS, around 2 cm above the olecranon for both right and left side of the thorax for the long axis and short axis images. Lung that is characterized in ultrasound by hyperechoic line (pleural line) with reverberation artifact can be visualized from the 7th until 11th intercostal space dorsoventrally. Recommendation for further study is to perform M-mode study of echocardiography to gain the cardiac measurement of the goat heart with more number of animals of variant size.

REFERENCES

- Boon, J. A. (2011). *Second Edition: Veterinary Echocardiography*. Wiley Blackwell.
- Brown, D., & Gaillot, H. (2008). Chapter Five: Heart. In D. Penninck, & M.-A. d. Anjou, *Atlas of Small Animal Ultrasonography* (pp. 151-215). Iowa: Blackwell Publishing.
- Flock, M. (2003). Diagnostic ultrasonography in cattle with thoracic disease. *The Veterinary Journal*, 272-280.
- Hallowell, G. D., & Potter, T. J. (2008, April 14). *ULTRASONOGRAPHY: ITS ROLE IN RUMINANT DIAGNOSIS*. Retrieved 3 February 2016, from Vet Times: <http://www.vettimes.co.uk/article/ultrasonography-its-role-in-ruminant-diagnosis/>
- Hallowell, G. D., & Potter, T. J. M. B. (2012). Reliability of quantitative echocardiography in adult sheep and goats. *BMC Veterinary Research*, 1-11.
- Hecht, S. (2008). Chapter Four: Thorax. In D. Penninck, & M.-A. d. Anjou, *Atlas of Small Animal Ultrasonography* (pp. 119-150). Iowa: Blackwell Publishing.
- Khosla, R. (2012). Retrieved 12 February 2016, from http://cdn.intechopen.com/pdfs/27888/InTech-Lung_sonography.pdf
- Kimberly Palgrave, B. B. (2015). *On-Farm Ultrasound Uses: Beyond Pregnancy Diagnosis Clinical Booklet with Easi-scan*. United Kingdom: BFC Technology Ltd.
- Kircher, P. R. (2011). Equipment. In F. Barr, & L. Gaschen, *BSAVA Manual of Canine and Feline Ultrasonography* (p. 222). England: BSAVA.
- Laura J. Armburst, D. D. (2011). *Ultrasonography of The Thorax: There's More Than Just The Heart!* CVC. Kansas.
- Lerouxr, A. A., Farnir, F., Moonen, M. L., Sandersen, C. F., Deleuze, S., & Amory, H. (2012). Repeatability, variability and reference values of pulsed wave Doppler echocardiographic measurements in healthy Saanen goats. *BMC Veterinary Research*, 1-10.
- Lichtenstein, D. A., Mezière, G. A., Lagoueyte, J.-F., Biderman, P., Goldstein, I., & Gepner, A. (2009). A-lines and B-lines: lung ultrasound as a bedside tool for predicting pulmonary artery occlusion pressure in the critically ill. *Chest*, 1014-1020.
- Mathew, J. P., & Kory, P. (2010). *Lung Ultrasound*. Retrieved 12 February 2016, from Critical Care Ultrasonography Forum: <http://www.critcaresono.com/page.php?page=27>

Seiler, G. (2011). Thorax. In F. Barr, & L. Gaschen, *BSAVA Manual of Canine and Feline Ultrasonography* (pp. 29-36). England: BSAVA.

Smith, M. C., & Sherman, D. M. (2009). *Goat Medicine*. Iowa: Wiley Blackwell.

Tharwat, M., Fahd Al-Sobayll, A. A., & Buckzinski, S. (2012). Echocardiography of the normal camel (*Camelus dromedaries*) heart: technique and cardiac dimensions. *BMC Veterinary Research*, 1-8.

