DEDICATION

To my Mother (Mona), Father,

My Brothers: Mohammed, Yassin, and Omer

To my Sister Safa

With great love

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Published papers extracted from this thesis

1- **Marwa-Babiker, A.M.; Ali, H.A.; Ibrahim, Z.H.; Ismail, H.I. (2015)**. Histology and histometry of the myocardial bridges of the heart during prenatal development in the dromedary camel (*camelus dromedarius*). *4th ISOCARD conference* (2015) proceedings, P. 376.

2- **Marwa-Babiker, A.M.; Ali, H.A.; Ibrahim, Z.H.; Ismail, H.I. (2015)**. Ultrastructure of prenatal heart of dromedary camel during first trimester. *Nova Journal of Medical and Biological Sciences.* **4** (3): 1-6.

3- **Marwa-Babiker, A.M.; Ali, H.A.; Ibrahim, Z.H.; Ismail, H.I. (2016)**. A morphological study on myocardial bridges of the dromedary camel heart during prenatal development. *International Journal of Advanced Research*. **4** (1): 1358-1365.

4- **Marwa-Babiker, A.M.; Ali, H.A.; Ibrahim, Z.H.; Ismail, H.I. (2016)**. Histology of sinoatrial node in the dromedary camel foetus. *Journal of Advanced Veterinary Science and Technology*. **5** (1): 226-231.

List of Abbreviations

A	Aorta, Arterioles
AT	Adipose Tissue
AVB	Atrioventricular Bundle
AVN	Atrioventricular Node
AVS	Atrioventricular Septum
BC	Blood capillary
CaVC	Caudal Vena Cava
CN	Connective tissue Nuclei
CT	Connective Tissue
CVC	Cranial Vena Cava
CVRL	Crown Vertebral-rump Length
EN	Endothelial nuclei
G	Ganglion
IV	Interventricular septum
IVB	Interventricular Branch
L	Liver
LA	Left Atrium
LAVO	Left Atrioventricular Orifice
LV	Left Ventricle
M	Myocardium
MBs	Myocardial Bridges
N	Nucleus
OCM	Ordinary Cardiac Muscles
P	Pericardium
PA	Pulmonary Arteries
PF	Purkinje Fibres
PIB	Paraconal Interventricular Branch
R	Rib
RA	Right Atrium
RAV	Right Atrioventricular Valve
RAVO	Right Atrioventricular Orifice
RV	Right Ventricle
SAN	Sinoatrial Node
SEM	Scanning Electron Microscopy
SPSS	Statistical Package for the Social Science
T	Trabiculae Carneae
TEM	Transmission Electron Microscopy

V	Vein, Venuole

Abstract

The aim of this study to investigate the morphology and morphometry of the pre-natal development of dromedary heart. Forty eight hearts of camel foetuses obtained from Al-Ssalam and Tamboul slaughterhouses, Sudan, were used in histological, histometric, ultrastructural and morphometric studies. Samples were collected during the period (December 2014-March 2015). The foetuses were divided into three age groups: first trimester (1-130 days), second trimester (131-260 days) and third trimester (261- 426 days). At the early stages the pericardium was associated with the diaphragm, liver and thoracic vertebrae. The atrial outlines were irregularly showing many undulations, whereas the ventricular outlines were relatively regular. The epicardium appeared as a thin layer which showed a gradual increase in thickness and amount of adipose tissue. As foetal age increased, a gradual increase was also observed in the myocardial thickness of the ventricular wall and atrial pectinate muscles. Sinoatrial node (SAN) in the second and third trimesters had the same location as in the adult and also had two types of cell as in other animal species. Atrioventricular node (AVN) was found close to the atrioventricular opening in the first trimester and close to the opening of the coronary sinus in the second and third trimesters. It generally appeared as a group of large-sized and lightly stained cardiac muscle cells. Atrioventricular bundle (AVB) was embedded in myocardium in the second trimester either between the endocardium and myocardium or within the myocardium in the third trimester. Purkinje fibres (PF) were embedded in the myocardium in the first trimester and either between the endocardium and myocardium or within the myocardium in the second and third trimesters. Myocardial bridges (MBs) were observed only histologically in the second and third trimesters. They appeared as bundles

of fibres of cardiac muscle which covered the interventricular branch of coronary artery either partially or completely. The thickness of MBs and the interventricular branch of coronary artery in the third trimester was significantly higher than that in the second trimester. Type II MBs were observed in the late stages of first trimester with SEM. MBs had a less developing transverse tubular system than the myocardium in the same stages. The heart during the first third of first trimester had approximately similar dimensions. The length increased more than the width during the late stages of the first trimester. The longitudinal groove started gradually as a shallow groove and the coronary groove was not observed until the end of the first trimester. The atrial pectinate muscles showed a wavy appearance at the early stages of first trimester and gradually developped and appeared as large branching and anastomosing plexiform cords at the second and third trimesters. Pectinate muscles were thicker in the second trimester than in the third trimester. There were no intercalated discs in the first and second trimester, whereas Z lines with irregular striations were present. They were first appeared in the third trimester. Mitochondria were numerous around the nuclei and between the fibrils. No significant differences were detected in ultrastructural morphometric measurements in the length of myofibrils in the first, second and third trimesters. The length and width of mitochondria in the second and third trimesters were constant. This was also true for the width of connective tissue nuclei and of myocardium in the three trimesters and connective tissue nuclei of MBs. Mitochondria in the first trimester was longer than that in the second and third trimesters. The sarcomere in the third trimester was significantly thicker. Connective tissue nuclei in the first trimester were longer than those of second and third trimesters. Connective tissue cells nuclei of MBs were longer in the third trimester than those of

myocardium. It is concluded that the development of camel heart is fully achieved through the three gestational ages (first, second and third trimesters).

المستخلص

تهدف هذه الدراسة لتقصى شكل وقياسات تطور قلب الجمل وحيد السنام قبل الولادة. جُلب ثمانية وأربعون قلباً من أجنة الإبل من مسلخى السلام وتمبول بالسودان، وأُستخدمت للدراسات النسيجية والقياسية والبنيوية الفائقة وقياسات البنية الفائقة. جُمعت العينات فى الفترة بين (ديسمبر 2014-مارس 2015). قُسمت الأجنة الى ثلاث مجموعات عُمرية: الأُثلوث الأول (1-130 يوم)، الأُثلوث الثانى (131-260 يوم) و الأُثلوث الثالث (261-426 يوم). يرتبط التامور فى المراحل المبكرة مع الحجاب الحاجز والكبد والفقارالصدرية. تبدو حواف الأذينات متعرجة بينما تكون حواف البطينات منتظمة نسبياً. يبدو النخاب كطبقة رقيقة حيث يزيد سمكه تدريجياً وكذلك النسيج الدهنى. بزيادة عمر الجنين توجد أيضاً زيادة تدريجية فى سمك عضل القلب فى البطينين والعضلات المشطية. تقع العقدة الجيبية الأذينية فى الأُثلوث الثانى والثالث فى نفس الموقع لدى الحيوانات البالغة ولها ايضاً نوعان من الخلايا كبقية أنواع الحيوانات. توجد العقدة الأذينية البطينية متاخمة للفتحة الأذينية البطينية فى الأُثلوث الأول ومتاخمة لفتحة الجيب التاجى فى الأُثُلوثين الثانى والثالث وتبدو كمجموعة من خلايا العضل القلبى كبيرة الحجم وباهتة الصبغة. توجد الحزمة الأذينية البطينية مغمورة فى عضل القلب فى الأُثلوث الثانى أو بين الشغاف وعضل القلب أو داخل عضل القلب فى الأُثلُوث الثالث. توجد ألياف بيركنجى مغمورة فى عضل القلب فى الأُثلوث الأول أو بين الشغاف وعضل القلب أو داخل عضل القلب فى الأُثلوثين الثانى والثالث. شُوهدت الجسور العضلية نسيجياً فى الأُثلوثين الثانى والثالث. ظهرت كحزم من الألياف القلبية تغطى فرع الشريان التاجى بين البطينين جزئياً أو كلياً. لُوحظ أن سمك الجسور العضلية وفرع الشريان التاجى بين البطينين يزداد معنوياً فى الأُثلوث الثالث أكثر من الأُثلوث الثانى. شُوهد النمط الثانى من الجسور العضلية فى مراحل متأخرة من الأُثلوث الأول بواسطة المجهر الألكترونى السطحى. وُجد أن نمو نظام التخطيط المستعرض يكون أقل فى الجسور العضلية عنه فى عضل القلب لذات المرحلة. وُجد أن أبعاد القلب فى الثلث الأول من الأُثلوث الأول شبه متساوٍ. توجد زيادة فى الطول أكثر من العرض خلال المراحل المتأخرة من الأُثلوث الأول. يبدأ تكون الأخدود الطولانى تدريجياً بينما لا يظهر الأخدود التاجى حتى نهاية الأُثلوث الأول. أظهرت العضلات المشطية مظهراً متموجاً فى المراحل المبكرة من الأُثلوث الأول ونمت تدريجياً وظهرت كضفيرة حبلية متفرعة ومتفاغرة فى الأُثلوثين الثانى والثالث. كانت العضلات المشطية سميكة فى الأُثلوث الثانى أكثر من الأُثلوث الثالث. لم تُشاهد الأقراص المقحمة فى الأُثلوثين الأول والثانى بينما لُوحظت خطوط Z بتخطيط غير منتظم، وظهرت

للمرة الأولى فى الأُثلوث الثالث. كانت هنالك متقدرات عديدة حول النواة وبين الليفات العضلية. لم ترصد إختلافات معنوية فى قياسات البنية الفائقة لطول الليفات العضلية فى الأُثلوث الأول والثانى والثالث. وُجد أن طول وعرض المتقدرات فى الأُثلوثين الثاني والثالث ثابت وينطبق ذلك على عرض نوى النسيج الضام فى المراحل الثلاثة ونوى النسيج الضام للجسور العضلية. لُوحظ أن طول المتقدرات فى الأُثلوث الأول أكبر من الأُثلوثين الثانى والثالث. وُجد أن للقسيم العضلى فى الأُثلوث الثالث سمكاً معنوياً. لُوحظ أن نوى النسيج الضام فى الأُثلوث الأول أطول من الأُثلوثين الثانى والثالث. وُجد أن طول نوى النسيج الضام للجسور العضلية أطول منه فى العضل القلبى. خَلُصَت الدراسة الى أن تطور قلب الإبل يكتمل كلياً خلال مراحل الحمل الثلاث (الأُثلُوث الأول والثانى والثالث).

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