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RESEARCH ARTICLE

A morphological study on myocardial bridges of the dromedary camel heart during prenatal development

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Abstract

Myocardial bridges (MBs) are cardiac abnormalities in which segments of coronary artery are embedded in myocardium. They are considered normal in adult dromedary camels. This study aimed to investigate the existence and morphology of foetal myocardial bridges in dromedary camels. 30foetuses obtained from Tambul and Al-Salam slaughterhouses, Sudan, were used in the study. They were divided into three equal groups: first trimester, second trimester and third trimester. Anatomical, histological and morphometric studies on myocardial bridges over descending branches of the coronary artery were done. MBs were absent in the first trimester, but they appeared frequently in the late and early stages of the second and third trimesters. They were in the form of parallel bundles of cardiac muscle fibres separated from the branches of coronary artery by loose connective tissue. The walls of MBs and descending interventricular branch of coronary artery were significantly thicker in the third trimester than those in the second trimester. It could be concluded that (MBs) are normal in camel foetus in the first and second trimesters; they increased in thickness with the increase in the foetal age.

Introduction:-

The dromedary camel (*Camelus dromedarius*) can survive under extremely harsh climatic conditions of the desert which are characterized by high temperature, little water and poor food.

Myocardial bridges (MBs) are congenital abnormalities in which a branch of the coronary artery passes through the myocardium (Kosinski and Grzybiak, 2001; Chen, et al., 2004; Singh, et al., 2005; Alegria et al., 2005; Demirsoy, et al. 2006). They are also described as structures that consist of cardiac muscles passing above the coronary arteries or their branches (Chen and Lin, 2003; Kosinski et al., 2004; Aytan et al., 2006). Coronary arteries could dip into the myocardial muscles for different lengths and reappear on the heart's surface; these muscles overly the segment of the epicardial coronary artery form the myocardial bridge (Loukas et al., 2006; Bharambe and Arole, 2008).

The myocardial bridge is associated with major adverse cardiac events including myocardial ischemia, myocardial infarction, stable or unstable angina pectoris, complete atrioventricular block or sudden death (denDulk et al., 1983; Chambers et al.; 1994; Akdemir et al., 2002). They were frequent components of phenotypically expressed hypertrophic cardiomyopathy (Basso et al., 2009). They are also reported to cause acute myocardial infarction in various clinical conditions with profound anaemia (Akdemir et al., 2002).

Rare morphological studies on dromedary camels considered the myocardial bridges as a normal phenomenon in adult animals (Marwa-Babiker and Taha, 2013; Marwa-Babiker et al., 2013). The average length and thickness of MBs in all segments of the coronary arteries ranged from 8 to 40 mm and from 1.6 to 5.0 mm, respectively (Ma et

al. (2013). However, to the best of our knowledge, there is no morphological study on the myocardial bridge of the developing dromedary camel foetus. Thus, the present work aims to investigate the anatomical, histological and morphometric characteristics of the MBs and associated branches of coronary artery in developing foetuses of dromedary camels.

Material and Methods:-

Animals:-

30 hearts of camel fetuses collected from Tambul and Al-Salam slaughterhouses, Sudan, were used. The fetuses were divided into three equal age-based groups: first trimester (1-130 days gestation), second trimester (131-260 days gestation) and third trimester (261days gestation - birth). The age of foetus was determined by using the equation of crown- vertebral rump length (Elwishy et al., 1981).

Histological Study:-

The hearts were immediately taken from foetuses after being removed from slaughtered female animals. They were cannulated and then injected with 10% buffered formalin. Careful dissection was performed to detect any myocardial bridges. Specimens, about 1cm thick, were taken from detected MBs of each heart and immersed in 10% buffered formalin. They were then prepared by routine histological procedure which included general histological stain (H&E), Van Geison's and Masson's trichrome for collagenous fibres and Verhoff's for elastic fibres were used (Bancroft and Stevens, 2008).

Morphometric Study:-

H&E sections (5 µm thick)of 16 foetal hearts (8 hearts from second trimester and 8 hearts from third trimester) were used for morphometric measurements of MB. Olympus microscope (CH20-Japan) with ocular micrometer lens X6 was used for measurements, which included the thickness of central and peripheral parts (edges) of the MB as well as the thickness of tunica intima, tunica media and tunica adventitia of the interventricular branch of coronary artery. The objective lenses X 40 and X10 were used to measure the thickness after calibrating the ocular scale of the microscope (Thienport et al., 1986). Nine measurements of each section were taken from each heart and the mean value was calculated. Data of the different morphometric parameters were statistically analyzed by the Student's t-test, and the difference was considered statistically significant at $p<0.05$.

Results:-

The myocardial bridges (MBs) were absent in the first trimester but they appeared in eight hearts out of ten in the second and third trimesters. In the second trimester, MBs appeared at the age of 132.5 days, whereas they appeared at the early stages of the third trimester (74cm: 268days). Most of the bridges were found in the right descending interventricular branch of coronary artery. They were of two types: type I and type II. In type I the descending interventricular branch of coronary artery was partially covered by one or two muscular bands. In type II the descending interventricular branch of coronary artery dipped in the myocardium without reappearing (Fig.1). Histologically, the bridge appeared in the form of centrally thin and peripherally thick bundles of parallel cardiac muscle fibres above the interventricular branch of the coronary artery and under the epicardium (Fig.2). The muscular bundles were either continuous or interrupted and were accompanied by collagenous fibres and adipose tissue; they were separated from the underlying interventricular branch of the coronary artery by a thick layer of loose connective tissue which contained blood vessels, adipose tissue, collagenous and elastic fibres (Fig. 3, 4)

The bridged interventricular branch of the coronary artery was irregular in shape and it consisted of thin layers of tunica intima and tunica media and a thick layer of tunica adventitia (Fig. 5). Tunica media was made up of 2-6 layers of smooth muscle fibres in the third trimester and of 2-4 layers in the second trimester (fig.4, 5). The tunica media was thicker under the MB than in other parts around the artery. Occasionally, the tunica media blends with the myocardium or myocardial bridge (Fig. 5).

Morphometric measurements of MBs in the second and third trimesters are shown in Fig. 6. The thickness of peripheral parts of MBs gave higher values than that in the central parts. The mean thickness of the central parts of MBs in the second trimester was (41.06±25.39µm) and that of its peripheral parts was (58.79±36.26µm). The mean thickness of the centre of MBs in the third trimester was (153.98±108.39µm) and it was (190.59±147.54µm) in the peripheries. The mean thickness of MBs (central and peripheral parts) of the third trimester (172.28±25.90µm) was significantly thicker than that of the second trimester (49.92±12.55µm).

The mean thickness of tunica intima and tunica media of the interventricular branch of the coronary artery in the second trimester was (19.78±8.89μm) and that of tunica adventitia was (36.96±27.48μm). The mean thickness of tunica intima and tunica media of the interventricular branch of the coronary artery in the third trimester was (31.02±10.28μm) and that of tunica adventitia was (66.42±15.73μm). The wall thickness (tunica media and tunica adventitia) of the interventricular branch of coronary artery of the third trimester (48.72±25.09μm) was significantly higher (28.38±12.16μm) than that of the second trimester.

Discussion:-

Review of the literature reveals that the vast majority of research on myocardial bridges has been carried out in humans (denDulk et al., 1983; Chambers et al.; 1994; Akdemir et al., 2002; Chambers et al., 2009; Basso et al., 2009). A few records are available on myocardial bridges in dromedary camels (Abdel-Magied, 1996; Marwa-Babiker and Taha, 2013). The latter authors consider myocardial bridges as a normal phenomenon in dromedary camel hearts.In the present investigation, type I and type II myocardial bridges appeared in 90% of the foetal hearts studied. Most of these bridges were located over the right descending interventricular branch of coronary artery. Type I and type II myocardial bridges were also reported in 90% of 20 adult camels, and in 72.7% of 11 camel foetuses in the descending interventricular subsinusal or paraconal branches of coronary arteries (Marwa-Babiker and Taha, 2013).The most common site of myocardial bridge is the anterior interventricular branch of the left coronary artery (Migliore et al., 2013).Other reported locations include the diagonal branch of the left coronary artery, the left marginal branch, inferior interventricular branch of the left coronary artery, right coronary artery, right marginal artery, and inferior interventricular branch of the right coronary artery (Lima et al., 2002; Loukas et al., 2006; Bharambe and Arole, 2008). However, all myocardial bridges have been mentioned to be located in the mid segment of the left anterior descending coronary artery (Migliore et al., 2013).

In the present study, the MB of camel foetus was separated from the underlying interventricular branch of coronary artery by connective tissues containing adipose tissue. In the adult camel the myocardial bridges are covered by large amounts of adipose tissue, which also infiltrate the cardiac muscles of the bridge (Abdel-Magied, 1996; Marwa-Babiker and Taha, 2013). It has also been mentioned that the dipped segments of the human coronary artery are separated from the cardiac muscles by adipose tissue (Verhagen et al., 2013).

In the adult camel, the thickness of MB ranges between 7-15mm (Erden et al., 2006).According to the present study, the thickness of MBs of the third trimester was significantly thicker than that of the second trimester; the thickness of the wall of the interventricular branch of coronary artery of the third trimester was significantly thicker than that of the second trimester. This indicates that the development rates of the wall of myocardial bridge and interventricular branches of coronary artery increases with the advancing age.

It is demonstrated that themyocardial bridge causes anatomical narrowing in the affected segments passing through the myocardium leading to ischemia, atherosclerosis or stenosis in the segment of the interventricular branch of the coronary artery proximal to MB resulting in many pathological conditions in humans (enDulk et al., 1983; Chambers et al.; 1994; Akdemir et al., 2002; Chambers et al., 2009).However, the present results showed that the myocardial bridge was a normal phenomenon in foetal dromedary camel hearts. Similar findings have also been reported in adult camels (Taha and Abdel-Magied, 1996; Marwa-Babiker and Taha, 2013). The dromedary camel is known to have unique behavioral and physiological characteristics in the desert harsh environment. For example, its cardiac rate is around 50 beats/ min, its blood pressure ranges from 76 to 115mmHg and blood volume is 93ml/Kg (higher than those observed in the majority of other domestic specie) (Ouajd and Kamel, 2009). Moreover, the camel could lose up to 30% of its body weight without noticeable effect while other mammals may die because of circulatory failure when they lose 12% of their body weight (Schmidt-Nielsen, 1964; Macfarlane and Howard, 1970). Thus, the assessment of MBs in the camel should not be limited to their anatomic and dynamic effects, but should also consider the biological and physiological particularities of this animal.

Figure Legends:-

Figure 1: Diagrams of two camel foetal hearts showing interventricular branch of coronary artery (C) covered by myocardial bridges (Arrows) type I (A) and type II (B).

Figure 2: Photomicrograph of camel foetal heart at third trimester with myocardial bridge bundles (Arrows) above the branch of coronary artery (C) and under the epicardium (E). Note the connective tissue (T) separating the artery from the bridge and myocardium (M). H&E Stain.

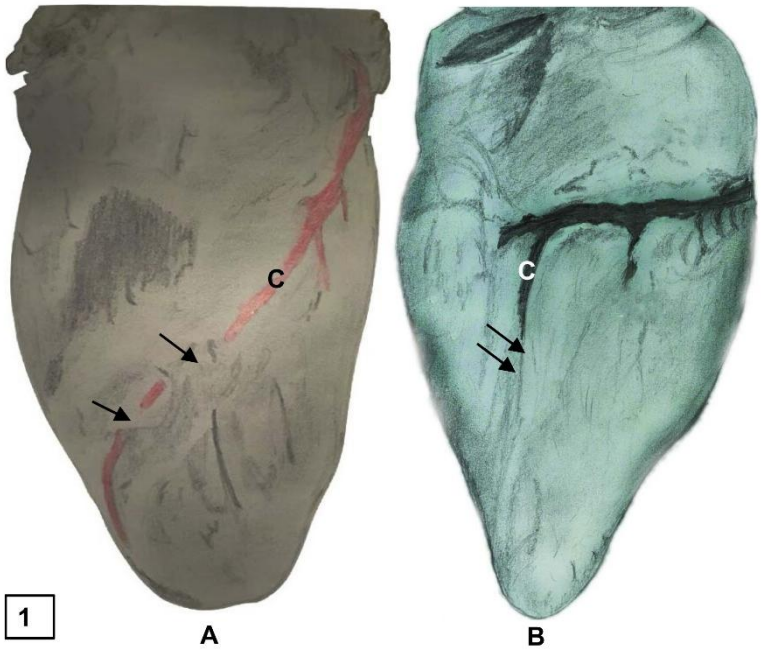
Figure 3: Photomicrograph of camel foetal heart at second trimester showing interrupted bundles of myocardial bridge (Arrows). Note the collagenous connective tissue (T) between the bundles and around the branch of coronary artery (C). Masson's Trichrome Stain.

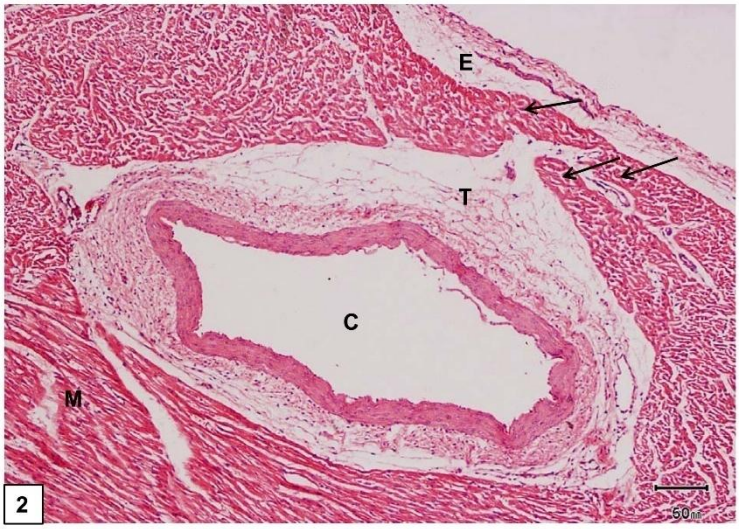
Figure 4: Photomicrograph of camel foetal heart at third trimester showing a thick myocardial bridge (Arrows). Note the thick underlying connective (T) of tunica adventitia with elastic fibres and adipose tissue around the irregular branch of coronary artery (C). Verhoff's Stain.

Figure 5: Photomicrograph of camel foetal heart at second trimester showing a thin myocardial bridge (Arrows). The muscles of myocardial bridge and myocardium (M) blend with the thin tunica media (T) of the branch of coronary artery (C). H&E Stain.

Fig. 6: Shows the thickness (µm) of myocardial bridge (MB) and wall of interventricular branch of coronary artery in the second and third trimesters. Values with significant difference ($P < 0.05$) are indicated with different letters (a,b).

Figures

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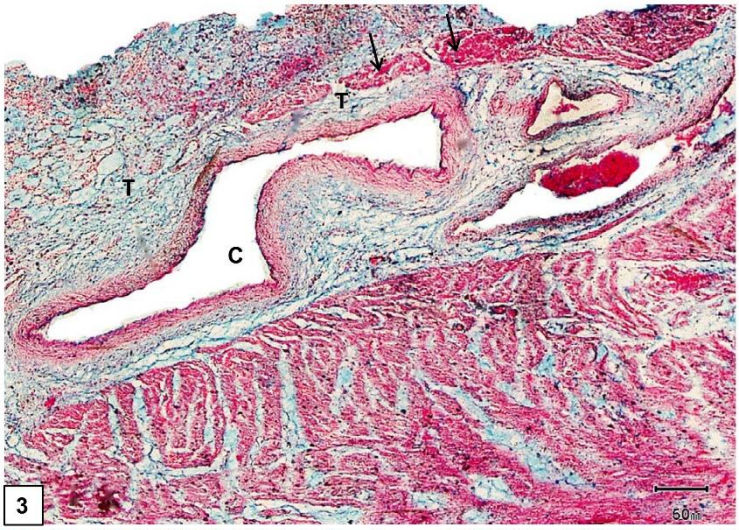
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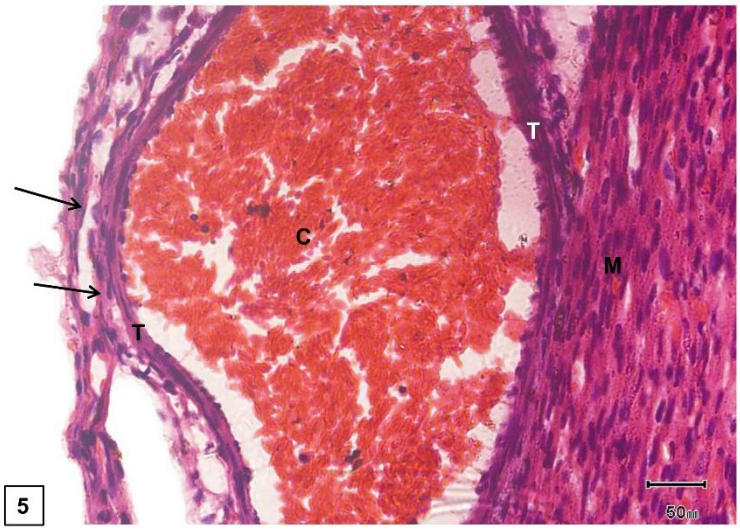

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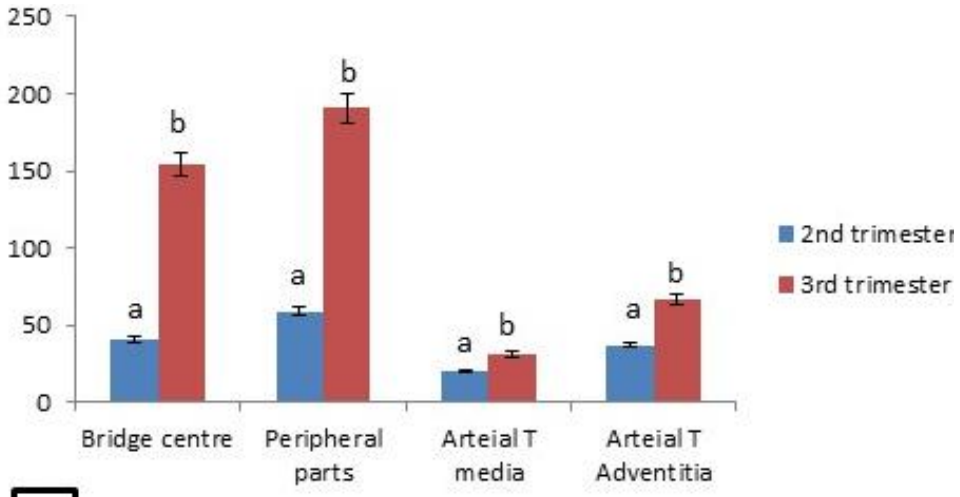

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