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MYOCARDIAL BRIDGES OF THE HEART OF THE DROMEDARY CAMEL *(Camelus dromedarius)*

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المستخلص

وجدت جسور العضلات القلبية فى 90% من قلوب الإبل ذات السنام الواحد البالغة التى تم تشريحها. تم تصنيف جسور العضلات القلبية الى نمطين وذلك طبقاً لكيفية تموضع الشريان تحت الجسر. النمط الأول فيه الفروع النازلة بين البطينين تحت الجيبى وجنيب المخروطى قد تم تجسيرها بواسطة حزمة أو حزمتين من ألياف العضل القلبى. النمط الثانى فيه الفروع النازلة بين البطينين تحت الجيبى وجنيب المخروطى تندغم فى العضل القلبى بدون معاودة الظهور مرة أخرى.

وجدت جسور العضلات القلبية فى ثمانية من قلوب الأجنة من إجمالى إحدى عشرة قلباً بنسبة 72.7%. سبع منها حوت النمط الثانى من جسور العضلات القلبية فى الفرع النازل بين البطينين تحت الجيبى (87.5%).

أظهر قلب واحد جسور العضلات القلبية فى الجانبين (12.5%). وجد فى هذا القلب أن الفرع النازل بين البطينين تحت الجيبى حوى النمط الأول بينما الشريان بين البطينين جنيب المخروطى حوى النمط الثانى.

Abstract

Myocardial bridges were found in 90% of dissected adult hearts of thedromedary camel. Myocardial bridges were classified into two types according to their relation with the overbridged artery. In Type I, the descending interventricular subsinuosal or paraconal branches were bridged by one or two bands of cardiac muscle, in Type II, the descending interventricular subsinuosal or paraconal branches were noticed to dip in the myocardium without reappearing. Eight out of eleven hearts of fetuses had myocardial bridges (72.7%); seven hearts had myocardial bridges of Type II

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category in the subsinuosal interventricular branch, (87.5%); only one heart showed myocardial bridges on both sides (12.5%). In this heart, Type I category was observed over the subsinuosal interventricular branch whereas Type II category was confined to the paraconal interventricular branch.

Key words: Camel, Heart, Myocardial bridges

Introduction

Myocardial bridge is defined as a congenital coronary abnormality in which a branch of a coronary artery runs intramurally through the myocardium (Kosinski and Grzybiak, 2001; Chen et al., 2004; Singh et al., 2005; Alegria et al., 2005; Demirsoy et al., 2006). It is also defined as structure consisting of heart muscle tissue which passes above the coronary arteries or their branches (Chen and Lin, 2003; Kosinski et al., 2004; Aytan et al., 2006). A third definition is that the coronary arteries may dip into the myocardium for varying lengths and reappear on the heart's surface, this muscle overlying the segment of the epicardial coronary artery is termed a myocardial bridge (Loukas et al., 2006; Bharambe and Arole, 2008). Review of the literature reveals that the vast majority of research on myocardial bridges has been carried out on humans. The most common site of myocardial bridge is over the anterior interventricular branch of the left coronary artery. However, 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).
As regards to the incidence of myocardial bridges in hearts of humans and their association to what branch of the coronary arteries, was superbly reviewed by (Alegria et al., 2005; Bharambe and Arole, 2008).

The incidence of myocardial bridges varies greatly in humans depending on the method of study. It is as low as 0.6 to 5.5% when assessed by coronary angiography (Angelini et al., 1983; Harikrishnan et al., 1999; Soran et al., 2009). On the other hand, when assessed by dissection, the incidence increased markedly ranging from 23 to 85.7% (Geiringer, 1951; Polacek and Kralove, 1961; Ferreira et al., 1991; Reig et al., 1990; Kosinski et al., 2004; Lujinovic et al., 2005; Loukas et al., 2006). In contrast to humans the research which was carried out on myocardial bridges in animals was meager. (Polacek and Zechmeister, 1968) have described three types of myocardial bridges depending on the intramural course of the branches of coronary arteries. Type I, branches of coronary arteries are entirely intramyocardial; Type II, branches of coronary arteries are predominantly

epicardial; and Type III, branches of coronary arteries are entirely epicardial. According to this classification they allocated each type to certain animals. Type I is found in rodents and lagomorphs; Type II is found in small ruminants; and Type III is found in large ruminants and equines. (van Nie and Vincent, 1989) studied myocardial bridges in a number of animals, including monkey, calves, sheep, goats, pig, dogs and seals. They showed that the myocardial bridges are located in four different sites; interventricular paraconal or subsinuosal branches, first grade branches of interventricular branches, second grade branches of interventricular branches, and multiple sides.

(Taha and Abdel-Magied, 1996) reported the constant presence of myocardial bridge overlying the subsinuosal interventricular branch in ten dissected hearts of the dromedary camel but have only observed myocardial bridges infrequently over the paraconal interventricular branch in three out of the ten dissected hearts. The myocardial bridges were observed crossing the middle third of the interventricular branches. The other study which was carried out in the dromedary camel (Erden et al., 2006) found that the incidence of myocardial bridges was about 35.29% (6 out of 17 dissected hearts). Of these six hearts five of them presented myocardial bridges on the left paraconal interventricular branch. Multiple bridges were observed in two hearts in the left paraconal interventricular branch. In all the six hearts the myocardial bridges were located in the middle third of the interventricular branches.

(Bezerra et al., 1989) have reported that myocardial bridges cover ¼th of the length of the paraconal interventricular branch in the one humped camel. They added that the right coronary artery did not present any myocardial bridges.

In the other study on the March deer; (Machado et al., 2002) have claimed that both paraconal and subsinuosal interventricular branches dipped in the myocardium without reappearing. (Santos et al., 2000) who dissected 30 hearts of adult bovines have indicated that myocardial bridges are present in all the hearts (100%). They claimed that 93.3% of the specimens showed multiple bridges that varied from two to six.

The objectives of this paper are to study the myocardial bridges grossly in the dromedary camel. In addition the myocardial bridges shall also be studied in the foetus.

Materials and methods

A total of 31 normal hearts were obtained from adult and foetus camels (*Camelus dromedarius*). Twenty hearts were from adult camels, the rest from foetuses (119-330 days of pregnancy). Of the 20 hearts, 19 were from females and only one from a male camel. The weight of hearts from adult camels varied between 1.3 to 3.7 kg. The ages of foetuses were determined by using the equation of crown-rump length of camel fetuses. The equation was described by (Elwishy et al., 1981) as follows $Y = 0.366X - 23.99$ depending on the Curved Crown-rump Length (CVRL), where, X = unknown fetal age in days and Y = body dimensions (cm).

Injection techniques were employed to study the blood supply of the heart; the left and right coronary arteries were cannulated first and then injected with red vinyl acetate. Then the injected hearts were immersed in 10% formalin for 15 days. Finally dissection was performed carefully to detect any myocardial bridges.

Results

Myocardial bridge was defined as a congenital anomaly of the myocardium in which normal epicardial interventricular branches of coronary arteries were bridged by one or two bands of cardiac muscle fibers (Type I), (Fig.1 and 2). However, there was another type of relation between the interventricular branches of coronary arteries and the myocardium observed in this study. In this type, the interventricular artery ran subepicardially in the subsinuosal or paraconal interventricular grooves and then dipped in the myocardium without reappearing (Type II), (Fig. 3 and 4). The artery was noticed to dip in the myocardium anywhere, proximally, in the middle, or distally in the interventricular grooves. Although the myocardial bridge was solely associated with the branches of the covering arteries yet in one heart a typical myocardial bridge was observed in relation to the great cardiac vein

(Fig.5). The incidence of myocardial bridges in the twenty dissected hearts of adult camels was 90%. Fifteen hearts (82.3%) showed myocardial bridges over both paraconal and subsinuosal interventicular arteries. The bridges which were associated with the paraconal interventricular artery were mostly of the Type I category (86.7%); Type II category represented (13.3%). Bridges associated with the subsinuosal interventricular artery were mostly of Type II category (66.7%); Type I category represented (33.3%). Two myocardial bridges (11.7%) were found solely in relation to the subsinuosal interventricular branch and the ratio of Type I to Type II categories was equal. Only one heart has shown myocardial bridge over paraconal interventriculaarn branch of the Type I category.

Eight out of eleven hearts of foetus had myocardial bridges (72.7%); 7 hearts had myocardial bridges in the subsinuosal interventricular branch of Type II category (87.5%), (Fig.6); only one heart had myocardial bridges on both sides (12.5%). In this heart, Type I category was found over the subsinuosal interventricular branch whereas Type II category was confined to the paraconal interventricular branch.

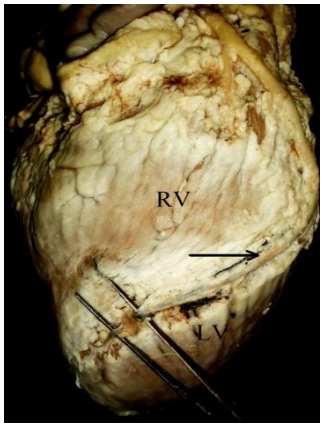

Fig1: Photograph of a dissection of the left aspect of the heart of the dromedary camel exhibiting the paraconal interventricular branch (arrow) covered by myocardial bridge (between the forceps) of the Type I category (about 1 cm wide) in the lower third of the paraconal groove. LV; left ventricle, RV; right ventricle.

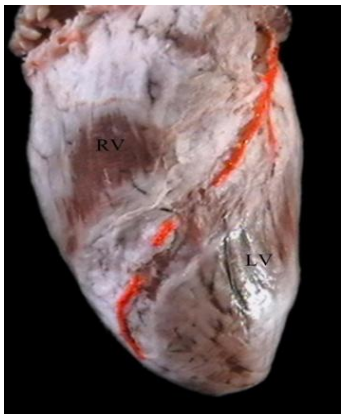

Fig 2: Photograph of a dissection of the left aspect of the heart of the dromedary camel showing two myocardial bridges of the Type I category on the paraconal interventricualr artery; one is located in the middle third and the other in the distal third of the artery (each one is about 2 cm wide). LA; left ventricle, RV; right ventricle.

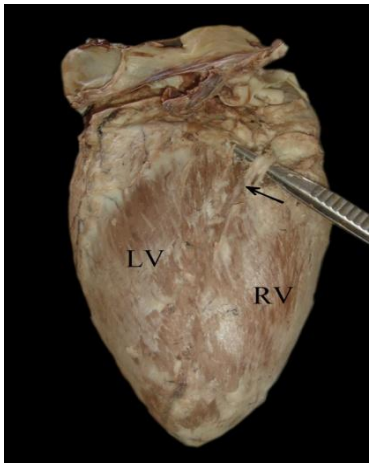

Fig 3: Photograph of a dissection of the right aspect of the heart of the dromedary camel revealing a myocardial bridge of the Type II category over

the proximal third of the subsinuosal interventricular artery. The arrow points to the site where the artery dips into the myocardium. LV; left ventricle, RV; right ventricle.

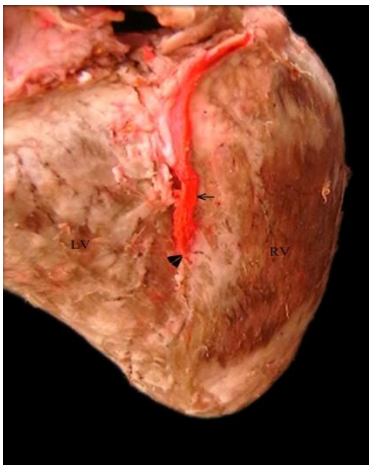

Fig 4: Photograph of a dissection of the right aspect of the heart of the dromedary camel revealing a myocardial bridge (arrow head) of the Type II category over the distal third of the subsinuosal interventricular artery (arrow). LV; left ventricle, RV; right ventricle.

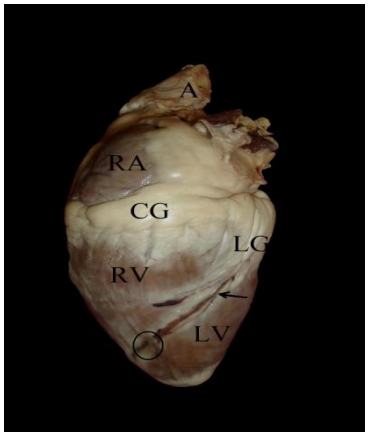

Fig.5: Photograph of a heart of the dromedary camel showing the great cardiac vein (arrow) covered by a myocardial bridge Type I category (circle) in the distal third of the paraconal groove; A; aorta, CG; coronary groove, LG; left longitudinal groove, LV; left ventricle, RA; right atrium, RV; right ventricle.

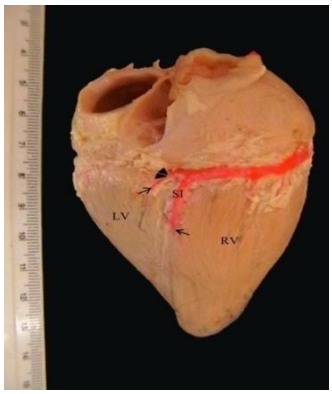

Fig.6: Photograph of a dissection of the right aspect of the heart of a foetus of the dromedary camel showing that the subsinuosal interventricular branch (SI) is covered by the Type II myocardial bridge in the middle part of the subsinuosal groove. The arrow points to the site where the artery dips in the myocardium. (Arrow head); the caudal branch of the right coronary artery, LV; left ventricle, RV; right ventricle.

Discussion

The muscle fibers of myocardium covering the coronary arteries or their branches were named myocardial bridges by (Geiringer, 1951). These bridges were extensively studied in humans using angiographic and dissection methods (Kosinski and Grzybiak, 2001; Chen and Lin, 2003; Alegria et al., 2005; Loukas et al., 2006; Bharambe and Arole, 2008) and less so in animals (Polacek and Zechmeister, 1968; Hadzielimoric et al., 1974; Bezerra et al., 1989; van Nie and Vincent, 1989; Taha and Abdel-Magied, 1996; Yamaguchi et al., 1996; Santos et al., 2007; Machado et al., 2002; Erden et al., 2006).

It appears that the incidence of the myocardial bridges depends mainly on the method of study; being low when assessed by angiography (Angelini et al., 1983; Harikrishnan et al., 1999; Soran et al., 2009) but increased greatly when assessed by dissection (Polacek and Karlove, 1961; Ferreira et al., 1991; Reig et al., 1990; Loukas et al., 2006; Kosinski, et al., 2004; Lujinovic et al., 2005). The low values which were reported in angiographic studies were possibly due to the fact that thick myocardial bridges perform weak compression and thus minimal systolic reduction of the lumen which can not be noticed by angiography (Channer et al., 1989; Ferreira et al., 1991; and Lujinovic et al., 2005). In some animals (camel, cattle) the incidence of myocardial bridges was 100% (Taha and Abdel-Magied, 1996; Santos et al., 2000). Most of myocardial bridges were associated with the anterior interventricular artery in humans (Loukas et al., 2006; Lima et al., 2002; Bharambe and Arole, 2008; Santos et al., 2007). In the animals (Monkey, calves, sheep, goats, pig, dogs, seals and camel) there was a controversy; whereas some authors (van Nie and Vincent, 1989; Taha and Abdel-Magied, 1996) believed that myocardial bridges were mainly present on the subsinuosal interventricular branches, others (Machado et al., 2002; Erden et al., 2006) were convinced that the bridges were present mainly on the paraconal interventricular branches. However, the present work does not support either of the two notions. Since the presence of myocardial bridges were observed on both subsinuosal and paraconal interventricular branches in about 82% of the hearts studied.

According to (Loukas et al., 2006) the presence of myocardial bridges appeared to be correlated to coronary dominance. Coronary dominance refers to the coronary artery which furnishes the posterior interventricular artery in humans (as defined in the text book of Gray's Anatomy, 1999) or the subsinuosal interventricular artery in animals. Since in the camel, the subsinuosal interventricular artery arises from the right coronary artery (Smuts and Benzuidenhout, 1987; Taha and Abdel-Magied, 1996) hence this is right coronary dominance. Therefore this explains the finding of (Taha and Abdel-Magied, 1996) that most of the myocardial bridges in the camel were related to the subsinuosal interventricular artery. Contrary to the hypothesis of (Loukas et al., 2006; Bharamble and Arole, 2008) who found that the maximum incidence of myocardial bridges was observed in relation to the left coronary artery in the case of the right coronary dominance.

The incidence of myocardial bridges in the twenty dissected hearts of adult camels was 90%. Fifteen hearts (82.3%) showed myocardial bridges over both paraconal and subsinuosal interventicular arteries. The bridges which were associated with the paraconal interventricular artery were mostly of the Type I category (86.7%); Type II category represented (13.3%). Bridges associated with the subsinuosal interventricular artery were mostly of Type II category (66.7%); Type I category represented (33.3%). Two myocardial bridges (11.7%) were found solely in relation to the subsinuosal interventricular branch and the ratio of Type I to Type II categories was equal. Only one heart has shown myocardial bridge over paraconal interventricularn branch of the Type I category.

Thepresentstudy showed the presence of myocardial bridges in the interventricular branches in the fetus of the camel for the first time. Eight out of 11 hearts had myocardial bridges (72.7%); seven hearts had myocardial bridges in the subsinuosal interventricular branch of Type II (87.5%) category; only one heart had myocardial bridges on both sides (12.5%). In this heart Type I category was found over the subsinuosal interventriculae branch while Type II category was confined to the paraconal interventricular branch.

These findings have shown that the presence of myocardial bridges is a normal feature in the heart of camel. There for it is unlikely to cause any circulatory problems (Marwa and Taha 2013, a and b).

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