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ORIGINAL PAPER

A Morphological Study of Myocardial Bridges in the Fetal Heart

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ABSTRACT

Introduction: *Myocardial bridges (MB) are congenital anomalies of hearts observed as muscle fibers covering epicardial branches of the coronary artery. The left anterior descending artery (LAD) was found to be commonly showing myocardial bridges (MBs). Clinically, MBs were claimed to cause varied symptomatology. The data on the morphology and prevalence of MBs in fetuses was limited, despite the commonly accepted congenital origin.*

Material and methods: *Fetal hearts obtained from 37 fetuses from the donation program were used. The hearts were dissected out from the thorax by standard dissection procedure. The pericardium and epicardium were dissected. The coronary arteries were delineated, and MBs were observed and noted. The coronary artery segment having MBs, its distance from the ostium as well as the direction and length of the MBs were studied.*

Results: *The MBs were observed in 20 out of 37 fetal hearts studied over the left anterior descending, right coronary, posterior interventricular and circumflex arteries. The mid or distal part of the coronary arteries frequently exhibited MBs. The mean length of the MB was 4.2 mm, with MBs being situated about 1.5 cm away from the coronary ostium. The oblique pattern of MB was more frequently noted.*

Conclusion: *The morphology and prevalence of fetal MBs showed common occurrence in the LAD artery, with a predominant oblique morphological pattern.*

Keywords: myocardial bridge, fetus, heart, coronary artery, congenital.

INTRODUCTION

A band of myocardial muscle fibers covering a short segment of the epicardial branches of the coronary artery forms myocardial bridges (MBs) (1, 2). The coronary vessels having MBs were called mural coronary or "tunneled in" vessels (3, 4). Myocardial bridges were described anatomically in both animals and humans (4, 5). At the same time, it is reported as just a systolic narrowing in the coronary artery during angiography (6).

Myocardial bridges were considered benign anatomical variants (7-9), yet they were reported to clinically vary from asymptomatic to causing sudden death. Moreover, the congenital anomalies of coronary vasculature were found to be encoded in genetics (10-12). Studies in human embryos showed the existence of an MB from the

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60 mm crown-rump stage, emphasizing the congenital origin of MBs (13, 14). The angiographic demonstration of the MB puts the argument for the post-natal acquired theory of origin (15). The difference in the ultrastructure of MB compared to the normal myocardium adds to the ambiguity of its origin (16).

The prevalence of MBs differs based on the modality used for identification in adults. The autopsy series noted the highest prevalence of MBs, ranging from 5%-86% (17), meanwhile the angiographic incidence of MBs was 0.5%-12% (18-20). The MBs were frequently noted in the LAD artery among all coronary arteries (2, 21, 22).

Despite being extensively reported in adults with developmental origin (16) and a debatable clinical significance (23), more research on the morphology of MBs in fetal hearts is needed. So, the present study was undertaken to observe the prevalence and morphology of MBs in fetal hearts toward aiming for early fetal coronary evaluation. ❑

METHODS AND MATERIALS

We carried out a cross-sectional study of 37 formalin-fixed fetal hearts from aborted, premature or term stillborn fetuses received as a part of the donation program with proper written consent from the parents. The study was conducted after institutional ethical clearance (IEC No.71). Fetuses with visible chest wall anomalies or reported cardiac anomalies were excluded from the study. By a midline approach, the thoracic cage was opened. The heart with the pericardium was identified and dissected, and coronary vessels were exposed. The coronary arteries were traced from their origin till their termination with observation of MBs along the course. In the coronary artery that exhibited the MB, the position of the MB to the course of the artery and its distance from the coronary ostium were noted. The observed MBs were morphologically categorized based on the direction of the fibers into oblique, transverse, and vertical bridges, and their length was measured. ❑

RESULTS

The gestational age of the studied fetuses ranged between 14 and 37 weeks, with a mean age of 24 weeks.

Coronary artery showing MBs – Thirty MBs were observed in 20 of the 37 fetal hearts studied (54.05%). Single MB was noted in 10 LAD and one left circumflex artery (LCx) (Figures 1, 3). Double MBs were observed in a single right coronary artery (RCA) (Figure 2). Seven fetal hearts showed MBs in two different arteries. Myocardial bridges were present in RCA and LAD in six fetal hearts, and one fetal heart showed MB in the RCA and posterior interventricular artery (Figure 4). In one of the fetal hearts, all three major coronary arteries had one MB each.

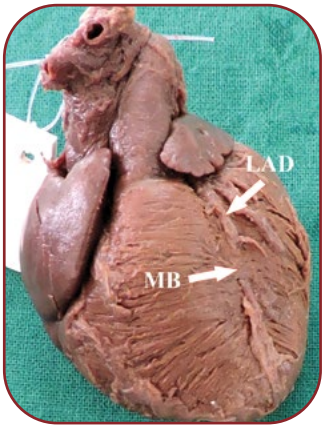

FIGURE 1. Fetal heart showing a transverse myocardial bridge (MB) in the mid part of the left anterior descending (LAD) artery

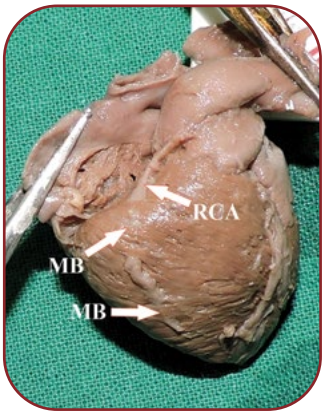

FIGURE 2. Fetal heart showing an oblique myocardial bridge (MB) in the mid part of the right coronary (RCA) artery

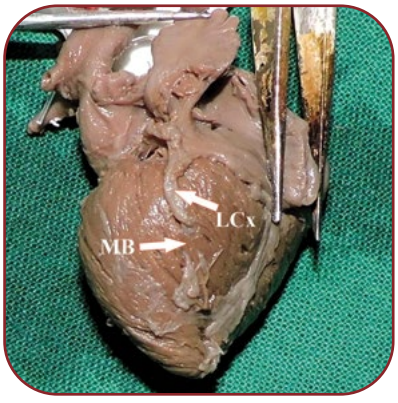

FIGURE 3. Fetal heart showing an oblique myocardial bridge (MB) in the mid part of the left circumflex (LCx) artery

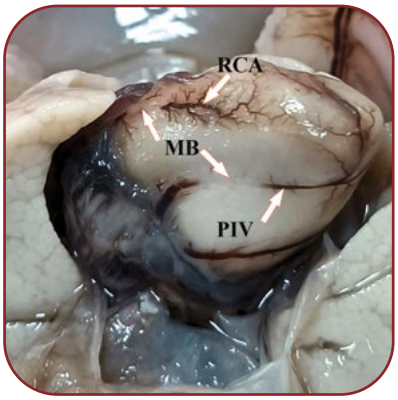

FIGURE 4. Fetal heart showing transverse MB in the proximal right coronary artery (RCA) and mid part of posterior interventricular (PIV) artery

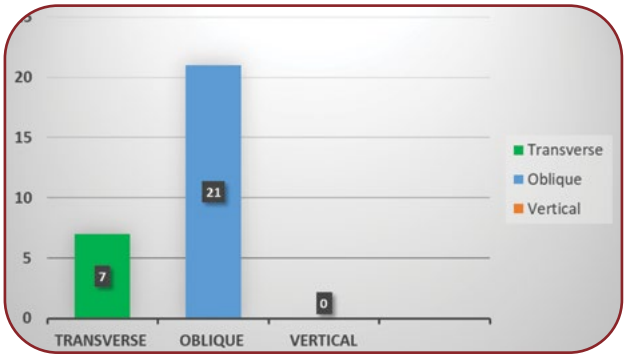

FIGURE 5. Morphological pattern of myocardial bridges

Position of MBs – Myocardial bridges were commonly observed to be located in the mid and distal segments of the artery (Figures 1, 2, 3), except in one fetal heart, where the MB was seen in the proximal segment of the artery (Figure 4).

Distance of MBs from the coronary ostium – The mean distance between MB and the coronary ostium was 1.5 cm.

Morphological pattern of MBs – All MBs were superficial type. The morphological pattern of MBs showed that the oblique direction of myocardial bridge fibers (Figures 2, 3) predominated over the transverse pattern (Figures 1, 4 and 5). The vertically oriented MB was not observed in the fetal hearts studied by us.

Length of MBs – The mean length of the MB was found to be 4.2 mm. ❑

DISCUSSION

The myocardial course of the epicardial coronary artery at certain places forms the MB phenomenon, having varied clinical importance (1, 2, 23). The time of MBs formation remains inconclusive. Few studies justified embryonic development (13, 14), while others pointed to the postnatal development of MBs (15). Another theory proposed that, despite the congenital origin of the MBs, their effect is exhibited only during adulthood (23, 24). The mammalian hearts were found to have subepicardial mesenchymal cells. The differentiation of these cells into the myocardioblast, along with the connective tissue from the subepicardial layer, formed the MBs over the coronary arteries (4, 5, 25). The development of MBs was theorized due to the abnormal reabsorption of subepicardial muscle due to the persistence of evolutionary genetics (26-29). Trifurcation of the left coronary artery and a pre-bridge branch were reported to be significantly associated with MBs in adult and pediatric hearts (30).

Apart from autopsy, MBs in living patients can be visualized through non-invasive imaging modalities like electron beam tomography, multi-slice computerized tomography, and transthoracic Doppler echocardiography (31). Based on the modality of the study, the prevalence of MBs differed among studies on adults (17-20). A 46.2% prevalence of MBs frequently observed in the LAD was reported in fetuses out of 38 hearts studied (Table 1). Unlike the present study, diagonal branch and posterior interventricular arteries were noted with MBs, whereas LCx was not observed to have MBs (26).

Morphologically, a superficial bridge perpendicularly crossing the artery, a deep bridge arising from the ventricular trabeculae, and an incomplete bridge appearing during adulthood has been described in MBs (32). The MB position, morphological pattern, length and distance from the coronary ostium observed in fetal hearts were similar to those reported in adult hearts (33-35).

The presence of long and thick MBs, more commonly in the proximal segment of the coronary artery in coronary heart disease patients, firmly established the interrelation between morphological features of MBs in causing pathological events (7, 33). Myocardial bridges caused varied pathophysiology in the arterial segment before and after the bridge (19). Significant intimal hyperplasia in the pre-bridge segment, helical-shaped endothelium in the bridged segment, and systolic narrowing were all reported to result in shear stress and predisposition to atherosclerosis formation (2, 33-37). Demonstration of Ki-67 activity coupled with decreased muscle and macrophage lowers the atherosclerosis threshold of the bridged

Study	Showed MBs	Single MBs	Double MBs	>2 MBs	Coronary artery with commonly observed MBs
Cakmak, *et al* (26)	18 out of 38 studied hearts	10	8	–	Left anterior descending artery
Present study	20 out of 37 studied hearts	11 *MB in the left circumflex artery observed	8 *Single artery with two MBs observed in one heart	1	Left anterior descending artery

TABLE 1. Comparison of studies on fetal myocardial bridges (MBs)

segment when compared to other parts of the artery. In addition, the endothelial dysfunction evidenced by the vasoactive response to acetylcholine in the transition segment showed the counteracting effect of the myocardial bridge (38, 39). Reports also claimed the technical difficulty posed by MBs in coronary bypass surgery, especially during exposure of the intramuscular segment (4, 23).

Multiple studies have reported inconclusive impact of MBs (2, 5, 16, 17, 22, 23), cardiac rhythm abnormalities like depression of QTc and monomorphic ventricular tachycardia were reported in children with hypertrophic cardiomyopathy with MBs (11). Direct compression of the coronary artery or the alteration of the distribution of atheroma by the MBs were the reasons for the strong association between MBs and coronary heart disease in young as well as old adults (33). Medical management and un-roofing surgery were the standard management strategies for symptomatic MBs. Non-invasive percutaneous stenting under intravascular ultrasound guidance has shown promising outcomes (40). The non-invasive imaging for diagnosis and management of MBs opens the possibility for early fetal stage evaluation of this condition.

Study limitation

The lack of information on the medical history and cause of death of the explored donated fetuses prevented the study of the causative association between MBs and fetal demise. The small sample size in each trimester limited the study of MBs grouped as per the trimester of gestation. The thickness of MBs could not be measured as the study was done on dead fetuses. ❑

CONCLUSION

The present study concluded that the myocardial bridge was present in 54.05% of all fetal hearts studied by us. The LAD showed the predominant presence of MBs in the explored fetuses along with an oblique MB pattern. This morphological study has provided the baseline information for designing a potential early fetal or neonatal non-invasive evaluation protocol for myocardial bridges. ❑

Conflicts of interest: none declared.
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