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BOVINE MYOCARDIAL BRIDGE MORPHOLOGY AND ASSOCIATION WITH CORONARY ATHEROSCLEROSIS

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ABSTRACT

Coronary arteries and their branches run through the subepicardial layer and penetrate the myocardium. In some cases, these vessels run intramyocardially for variable lenghts and then return to the subepicardial surface. The cardiac musculature that covers these vessels is known as a myocardial bridge. The presence of a myocardial bridge may protect the covered arterial segment against the development of atherosclerosis. In this report, we examined the pre-, post- and myocardial bridge segments of branches of bovine coronary arteries and compared them to corresponding sections of coronary arteries not covered by a myocardial bridge, in order to establish a possible morphofunctional association. Twelve interventricular paraconal branches from coronary arteries with or without a myocardial bridge (pre-, post- and myocardial bridge segments) were obtained from adult bulls of mixed breed. The samples were processed and stained to detect elastic, collagen and muscle fibers and were analyzed by light microscopy. The histological appearance of the pre-myocardial bridge segments differed from that of the other segments with or without a myocardial bridge in that the intimal layer was well-developed. By analogy, the morphology of the pre-myocardial bridge in bovine vessels suggests that there may be a high incidence of atherosclerosis in the pre-myocardial bridge tissue of human vessels.

Key words: Atherosclerosis, bovine, coronary artery, histology, myocardial bridge

INTRODUCTION

Coronary arteries and their branches run through the subepicardial tissue and penetrate the myocardium. In some cases, these vessels run intra-myocardially for variable lengths and then return to the subepicardial surface. The cardiac musculature that covers these vessels is known as a myocardial bridge [5,6].

The clinical importance of myocardial bridges (MB) in man was initially studied by Geiringer [7] and Lee and Wu [8], who referred to MB as an important factor in protecting against the development of atherosclerosis. These authors suggested that the support provided by the surrounding myocardium minimized the stress on the "mural" coronary artery. Muscular constriction could facilitate the local blood flow. Porstmann and Iwing [10] referred to this phenomenon as a milking effect and in angiographic studies they described a typical systolic transient narrowing of the artery under MB. In biochemical studies, Shinjo *et al*. [12] found significant amounts of dermatan and heparan sulfates in the intima and medium layer of human coronary arteries, and suggested that these glycosaminoglycans may protect the myocardial arterial segment against atherosclerosis.

Although MB can protect the covered arterial segment, in man there is a significant increase in the incidence of atherosclerosis in the vessel segment immediately before the MB [7,8].

Ying *et al*. [13] observed MB in 27.6% of human fetuses, indicating that this structure has a congenital origin. The anterior interventricular branch of the left coronary artery is the most frequently affected artery [7-10]. In pigs, MB were reported in 32% of hearts [4], whereas in bovine and dogs the frequency is 100% [11] and 45.6% [1], respectively.

In this report, we studied the histology of a branch of the bovine coronary artery containing a MB. The section covered by the MB as well as segments before and after this structure were examined in order to determine whether there was any morphofunctional correlation with the anterior interventricular branches of human coronary arteries.

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MATERIAL AND METHODS

Twelve intraventricular paraconal branches of coronary artery with or without MB and their pre-MB and post-MB segments were obtained from 12 adult bulls of mixed breed. There were no significant differences in the size and weight of the hearts used. One pre-MB, MB and post-MB segment was obtained from each of the 12 hearts and a 0.8 cm portion from the central region of each segment (total length ± SD: 4.0 ± 0.6 cm), except the post-MB segment, was analyzed. The luminal diameter of the pre-MB, MB and control segments was 0.51 ± 0.01 cm (mean ± SD), while that of the pos-MB segments was 0.48 ± 0.02 cm (n=12 each). The samples were fixed in 10% formol solution for 10 days and then dehydrated in an increasing alcohol series, clarified in xylene and embedded in paraffin. Serial sections (5 µm thick) were cut along the major axis of the vessel and were stained by the Verhoeff method for elastic fibers and by the Azan methods for collagen and muscle fibers.

The thicknesses of the segments were expressed as the mean ± SD (in µm), and were compared using Student's t-test. A value of $p < 0.05$ indicated significance.

RESULTS

Myocardial bridges were found in nine of the 12 hearts. All coronary branches were analyzed by light microscopy, with a total of nine intermediate MB (pre-MB), nine MB and nine post-MB segments being examined. For the control hearts without MB, three independent vessel samples from each of the segments (proximal, intermediate and distal) were examined.

Figure 1 shows an anterior intraventricular branch of the coronary artery covered by an MB. The pre-MB and post-MB segments are also visible. Histological analysis showed that the intimal layer was thick and well-developed in the pre-MB segment (Fig. 2A) and contained elastic fibers, as shown by Verhoeff's staining (Fig. 2A, inset). This aspect was not seen in the other segments analyzed, including the control segments (Fig. 2B). The medium layer was well-developed in all arterial segments and had a typical muscular appearance, as shown by Azan's staining. This muscle layer consisted of circular and longitudinal muscle fibers. The muscle fibers of the MB segment (Fig. 2C) generally showed the same morphological characteristics as cardiac muscle fibers. A well-developed adventitial layer and periadventitial tissue (fibrous connective tissue and adipose layers) were seen in all segments (Fig. 2), whereas in the MB segment they were found only in a region delimited by the muscle fibers (Fig. 2C). The morphology of the post-MB branches was similar to that of the control coronary segments.

Three segments (proximal, intermediate and distal) of coronary arteries without MB were used as control tissues and shared the same standard histological pattern. This pattern was similar to that of the pre-MB segments, except for a reduced or absent thickening of the inner layer. Figure 2A shows the histological appearance of a proximal segment that was used as control for the pre-MB segments.

Table 1 shows the staining results for the intimal, medium and adventitial (external) layers analyzed here. There were no significant differences between the thickness of each segment and its corresponding control. However, the pre-MB intima (46.2 ± 0.8 µm) was significantly thicker than the pre-MB intima of control vessels (proximal segment, 14.1 ± 0.7 µm; $p < 0.001$).

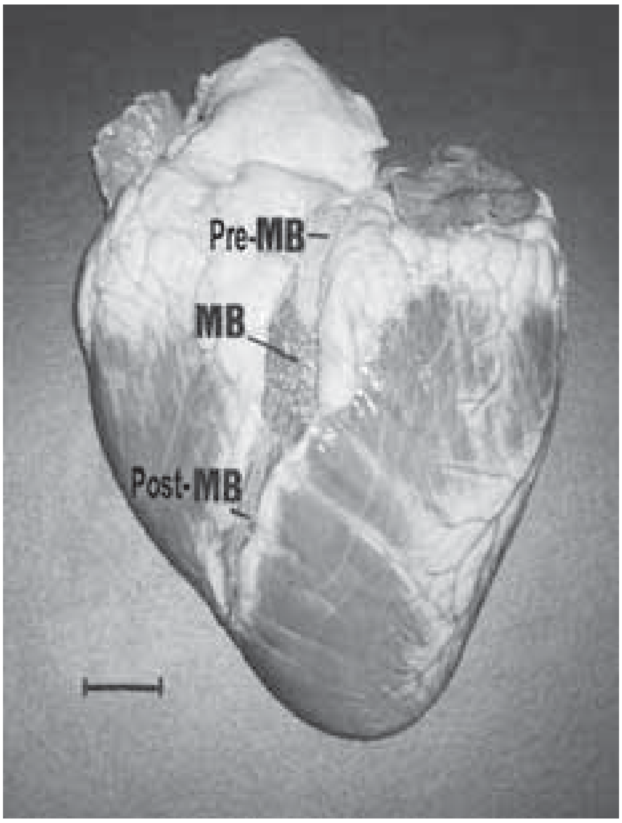

Figure 1. Gross anatomical aspect of an interventricular paraconal branch of an adult bovine coronary artery with a myocardial bridge. **Pre-MB** - pre-myocardial artery segment, **MB** - myocardial bridge, **Post-MB** - post-myocardial artery segment. Bar = 2 cm.

DISCUSSION

The histological characteristics of the bovine pre-MB segments examined here were similar to those seen in adult human [8], but differed from those of dog and pig pre-MB coronary artery segments [1-4] and also human fetuses, neonates and children [13].

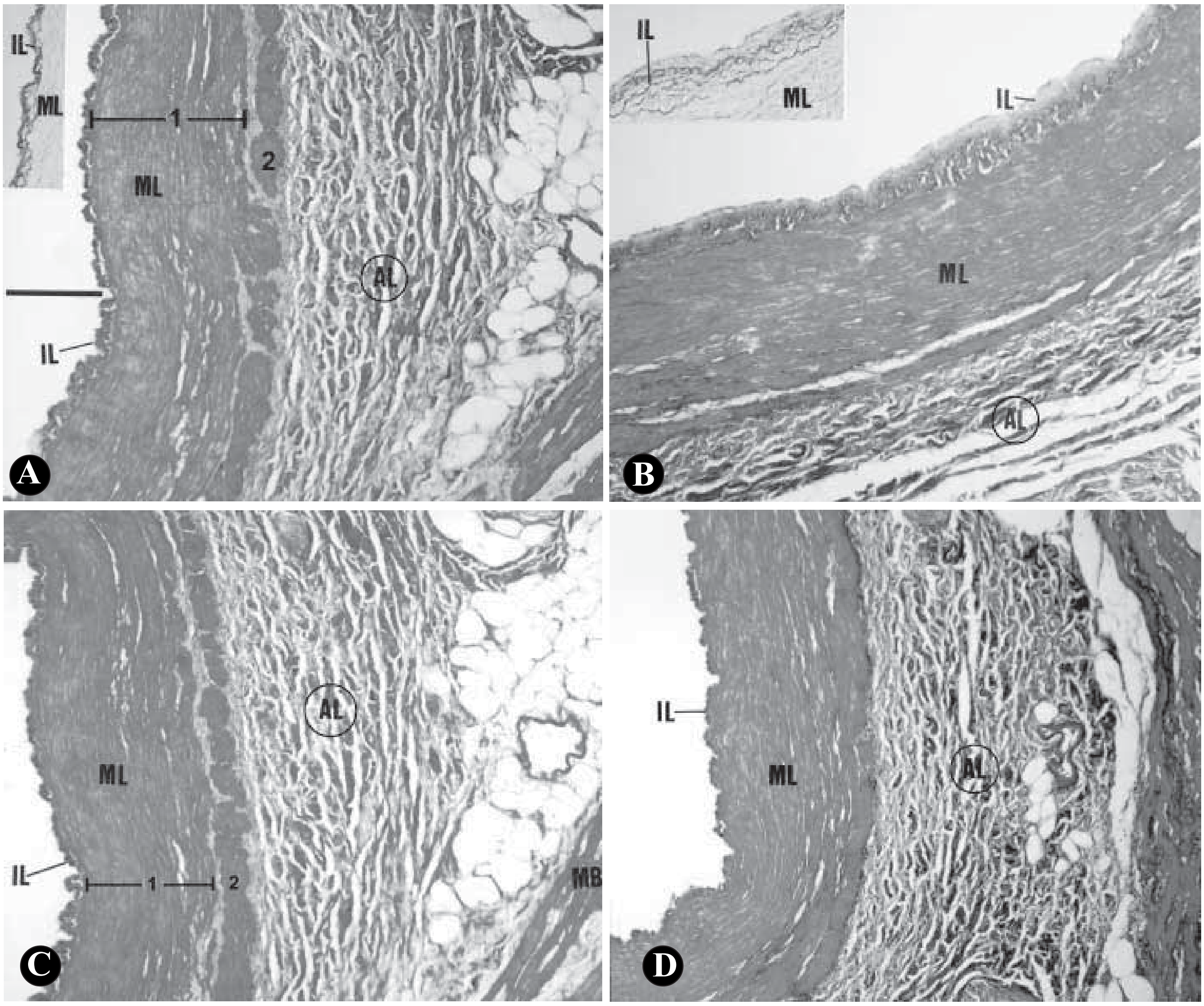

Figure 2. Light microscopy of an anterior interventricular branch of adult bovine coronary artery with a myocardial bridge. **A)** Pre-myocardial artery segment. **B)** Proximal artery segment (control). **C)** Myocardial bridge. **D)** Post-myocardial artery segment. The tissues were stained by Azan's method (large figures) and Verhoeff's method (insets). **AL -** adventitial and periadventitial layers, **IL -** intimal layer, **MB -** myocardial bridge, **ML -** muscular layer, **1)** Circular muscle layer, **2)** Longitudinal muscle layer. Bar = 150 µm for all panels. Verhoeff's method was used to show mainly elastic fibers, whereas Azan's method was used to stain the medium (muscle) and external layers. *p < 0.05.

Table 1. Thickness of the intraventricular bovine coronary artery segments.

Segments	Intimal	Medium
With MB		
Pre-MB (n = 9)	46.2 ± 0.8*	318.1 ± 17.1
MB (n= 9)	13.8 ± 0.6	306.2 ± 21.2
Post-MB (n = 9)	13.7 ± 0.6	298.5 ± 29.4
Without MB (Control)		
Pré-MB (n = 3)	14.1 ± 0.7	315.2 ± 25.1
MB (n = 3)	13.2 ± 0.8	299.1 ± 28.5
Post-MB (n = 3)	13.5 ± 0.8	289.6 ± 32.5

Pre-MB - pre-myocardial artery segment, MB - myocardial bridge, Post-MB - post-myocardial artery segment. The values (in µm) are the mean ± SD of the number of vessels indicated. * p < 0.001 compared to the corresponding control segments.

In bovine hearts, the intimal layer is rich in elastic fibers, as shown in the present work by staining with Verhoeff's method.

In man, the myocardial bridge is an important protective factor against the development of atherosclerosis [7,9]. In contrast, there is an increase in the incidence of atherosclerosis in the arterial pre-MB segment [7,8]. The rectangular space delimited by the muscle fibers in the MB segment could dampen the compressive effect of the systolic contraction that occurs in human hearts with MB.

As in human MB segments, the absence of a well-developed intimal layer under the myocardial bridge could be associated with the protection against the development of atherosclerosis in bovine hearts. Together, these results indicate that the intimal layer of the pre-MB segment of bovine coronary artery may have an as yet unidentified novel function.

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