

# Myocardial bridges: Cadaveric study

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## Abstract

Coronary arteries are characterized by subepicardial localization. The intramyocardial segment of epicardial coronary artery is termed as myocardial bridge (MB). MB has been considered as a benign condition which remains silent in majority of cases, MB has been associated with complications like angina, arrhythmia, transient ventricular dysfunction, decreased left ventricular function. New imaging techniques have led to improved identification and functional quantification of myocardial bridging in vivo and hence for commencing appropriate therapy. Present study was carried out in 100 formalin fixed adult cadaveric hearts irrespective of gender. The overall incidence of myocardial bridges was found to be 54% with left anterior descending artery showing highest prevalence. An attempt to find correlation between dominance of coronary circulation with myocardial bridges was done.

**Key Words:** angina, coronary artery, dominance, left anterior descending artery, myocardial bridge

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## INTRODUCTION

The main arteries and major branches of coronaries are usually subepicardial, but those in the atrioventricular and interventricular grooves are often deeply sited, and occasionally hidden by overlapping myocardium or embedded in it<sup>1</sup>.

The coronary artery may dip into the myocardium for varying lengths and then reappear on heart's surface. This segment of coronary artery present below the thickness of myocardium is known as tunneled artery and the myocardium overlying it is known as myocardial bridge. MB was first recognized more than 200 years ago. It was first described by Reyman in 1737<sup>2</sup>. The first postmortem observation was reported by Geiringer<sup>3</sup> in 1951 and was followed by the first radiological description by Portman and Iwig<sup>4</sup> in 1960. In 1951 Geiringer referred to over

bridged arteries as mural coronaries and suggested that in their intramyocardial segments these vessels are protected from obstructive atherosclerosis. The frequency of myocardial bridging reported in autopsy, cadaveric and radiologic studies has varied considerably (from 0.5 to 86%)<sup>5, 6, 7, 8, 9, 10</sup>. It has been considered as a normal variant or a benign coronary anomaly<sup>11, 12</sup>. However, reduced coronary flow reserve and an altered vasoreactivity have been documented in arteries with an intramuscular segment.<sup>12,13,14</sup> Moreover, myocardial bridging may present a technical challenge during coronary arterial bypass surgery because surgical exposure of intramuscular coronary artery may be difficult, may result in accidental opening of chambers of heart<sup>12</sup>. Conversely it has been proposed that the intramyocardial parts of arteries may be protected from atherosclerosis when compared with vessels of the same heart that do not form bridges. However, the proximal segment of bridged vessel is more susceptible to development of atherosclerotic lesions because of local hemodynamic disturbances<sup>15</sup>. Traditionally considered as benign condition, MB has been associated with non Q wave and even Q wave myocardial infarctions, myocardial stunning or hibernation, ischemia, coronary spasm, acute coronary syndrome, exercise induced A-V conduction block, ventricular septal rupture, early death after cardiac transplantation and sudden death, due to

coronary blood flow reduction to peripheral myocardium<sup>16,17,18</sup>. A high prevalence has also been reported in heart transplant patients and in patients with hypertrophic obstructive cardiomyopathy (HOCM)<sup>19</sup>. With each systole the coronary artery is compressed. The degree of coronary obstruction by myocardial bridge depends on factors such as its location, length and thickness of muscle bridge and degree of contractility.

## MATERIALS AND METHOD

**Inclusion criteria-** hearts without evidence of gross external pathologies

**Exclusion criteria-** hearts with evidence of gross external pathologies like cardiomyopathy, pericarditis and malignancies.

**Aim** -To study the incidence of myocardial bridges over major branches of right and left coronary arteries.

### Objective-

1. To measure the length of myocardial bridges
2. To find the correlation between cardiac dominance and myocardial bridges

### Materials-

Dissection instruments- Scalpel, small scissors (one each of straight and curved), toothed and plain forceps, Vernier caliper, Black silk suture material, Ruler, Acrylic colours and painting brush.

## Methods

A total of 100 cadaveric human hearts irrespective of sex were studied. All the parameters were studied by dissection method. The hearts procured from dissection hall were thoroughly washed under running tap water to remove clots. The entire course of Right and Left coronary arteries was traced by cleaning the epicardium and fat in piecemeal. The sites where branches were overlapped by the myocardium were preserved. The right coronary artery (RCA) was dissected from its origin to the posterior interventricular groove and some area beyond this region along the atrioventricular groove. The RCA was divided into 1<sup>st</sup> segment from its origin to right border of heart, and 2<sup>nd</sup> segment from right border to commencement of posterior interventricular artery (PIVA). PIVA was traced into the groove of same name till it became too small to dissect. Similarly the Left coronary artery (LCA) was dissected from its origin. The numbers of terminal branches originating from the main trunk of LCA were determined. The anterior interventricular artery (AIV) extending from its origin to apex of heart and beyond it was dissected. The circumflex artery (Cx) from its origin to the posterior interventricular groove was traced. When the length of MB was small it was measured directly with Vernier caliper but when the MB was long enough along the curved heart surface its length was measured with a silk segment and then with Vernier caliper for accurate measurements. Depending on the PIVA the coronary dominance was determined.

## RESULTS



**Figure 1:** MB located on middle 1/3<sup>rd</sup> of AIV artery **Figure 2:** Method of measuring length of MB **Figure 3:** MB on 1<sup>st</sup> segment of RCA

**Table 1:** Overall incidence of MB

MB	Frequency	Percent
Present	54	54.00
Absent	46	46.00
<b>Total</b>	<b>100</b>	<b>100</b>

**Table 2:** Distribution of MBs on LCA and RCA

MB	Frequency	
	LCA	RCA
Present	51	08
Absent	49	92
<b>Total</b>	<b>100</b>	<b>100</b>

Various branches of LCA appeared to be more affected by MBs than RCA (Table no. 2).

**Table 3:** Distribution of MBs on individual branches of LCA

Branch	MB	Frequency	Percent
AIV	Present	47	47
	Absent	53	53
Diag	Present	11	11
	Absent	89	89
Cx	Present	2	2
	Absent	98	98

(AIV- anterior interventricular artery, diag-diagonal, Cx- Circumflex)

Since the AIV branch seemed more prone to have myocardial bridges it was studied in detail by dividing it into three approximately equal segments as proximal, middle and distal. Though any part of AIV can be under MB, almost 25% of the MBs were located in middle segment of it. 16% specimens revealed MBs in its proximal segment and 6% revealed it in distal segment of AIV (TableNo.4).

**Table 4:** Distribution of study group as per location of MBs on segments AIV artery

MBs location on AIV	Frequency	Percent
Proximal	16	16
Middle	25	25
Distal	6	6
No bridge	53	53
<b>Total</b>	<b>100</b>	<b>100</b>

**Table 5:** Distribution of MBs on individual branches of RCA

Branch	MB	Frequency	Percent
1 <sup>st</sup> segment	Present	06	06
	Absent	94	94
2 <sup>nd</sup> segment	Present	00	00
	Absent	100	100
PIVA	Present	2	2
	Absent	98	98

The 1<sup>st</sup> segment of RCA appeared to be affected by MBs more and the 2<sup>nd</sup> segment was not affected at all. The dominance of the coronary circulation was determined by PIVA given by RCA or LCA. An effort was made to correlate between dominance and presence of MBs. This correlation was checked for each branch of LCA and RCA. But there was no significant co-relation found between the dominance and MBs.

**Table 6:** Dominance pattern of Heart

Dominance	Frequency	Percentage
Right	84	84.00
Left	16	16.00
<b>Total</b>	<b>100</b>	<b>100.00</b>

It was seen that 84% of specimens were showing right and 16% were showing left dominance pattern. No co dominance or balanced circulation pattern was observed.

**Table 7:** Association among study groups between Dominance and MBs on RCA

Dominance		MBs on RCA		Total
		Present	Absent	
Right	Count	8	76	84
	Percent	9.5%	90.5%	100.0%

Left	Count	0	16	16
	Percent	0.0%	100.0%	100.0%
Total	Count	8	92	100
	Percent	8.0%	92.0%	100.0%

There is no significant association of MBs over right circulation and left dominance. However, the MBs in right circulation are exclusively present with the right dominant circulation.

**Table 8:** Association among study groups between Dominance and MBs on LCA

Dominance		MBs on LCA		Total
		Present	Absent	
Right	Count	43	41	84
	Percent	51.2%	48.8%	100.0%
Left	Count	8	8	16
	Percent	50.0%	50.0%	100.0%
Total	Count	51	49	100
	Percent	51.0%	49.0%	100.0%

The above table shows that there is no significant association of MBs over left circulation and left dominance, however, the MBs in left circulation are common with right dominant circulation. Since AIV is most common branch to be involved in myocardial bridging, and to have various clinical manifestations due to MBs, than any other branch of both the coronaries, the association if any, between the dominance of heart and myocardial bridging on AIV branch was assessed.

**Table 9:** Association among study group, between dominance and location of MB on AIV according to its segments

Dominance		AIV bridge location				Total
		Prox	Mid	Dist	No bridge	
Right	Count	14	21	5	44	84
	Percent	16.7 %	25.0%	6.0%	52.4%	100.0%
Left	Count	2	4	1	9	16
	Percent	12.5%	25.0%	6.3%	56.3%	100.0%
Total	Count	16	25	6	53	100
	Percent	16.0%	25.0%	6.0%	53.0%	100.0%

(Prox-proximal, mid-middle, dist-distal)

The incidence of MBs over AIV was more in right dominance.

## DISCUSSION

A considerable number of studies and reports have enhanced our understanding of the pathophysiological mechanisms involved in the complications caused due to MBs. MBs must be considered especially in patients at low risk for coronary atherosclerosis but with angina like chest pain or established myocardial ischemia. The following table compares the incidence of MBs by various authors. These are autopsy studies.

**Table 10:** Incidence of MBs by dissection method

	Sample size	% of incidence of MB	LCA					RCA	
			Prox	Mid	Dist	Diagonal	Circumflex	1 <sup>st</sup> seg	PIVA
Geiringer E <sup>3</sup>	100	23	Over AIV only						
Edward JC <i>et al</i> <sup>5</sup>	276		5						
Polacek P <i>et al</i> <sup>6</sup>	70		60						
Ferreira AG Jr <i>et al</i> <sup>9</sup>	90	55.60	Arteries not specified						
Reig J <i>et al</i> <sup>20</sup>		58	All coronary arteries						
Venkateshu KV <i>et al</i> <sup>21</sup>	106	14.2	AIV and left diagonal artery						
Kosinski <i>et al</i> <sup>22</sup>	100		33			5			4
Lima VJ <i>et al</i> <sup>23</sup>	30		13.33	86.66					
Loukas M <i>et al</i> <sup>24</sup>	200	34.50	17.50	7		7.50	2.5	4	6
Bharambe VK <i>et al</i> <sup>25</sup>	50	56	20	28	8	16	8	4	6
Saidi H <i>et al</i> <sup>26</sup>	109		1	39	3		2	2	
Present study	100	54	16	25	6	10	2	6	2

The overall highest incidence of myocardial bridging was noted as 58 % by Reig J *et al*<sup>20</sup> in 1993. The present study found the overall incidence as 54%. The highest incidence of MBs, 25%, in present study was found in middle 1/3<sup>rd</sup> segment of AIV branch which is consistent with findings of Bharambe VK *et al*<sup>25</sup> in 2008. The highest 6% incidence of MBs over 1<sup>st</sup> segment of RCA is noted in the present study. Regarding MBs on AIV artery the findings are co-incident with the previous authors. In present study the maximum length of MB in AIV artery was in middle third segment being 65.1mm. The maximum lengths in diagonal, circumflex branches of LCA were 67.88 and 37.68mm and in 1<sup>st</sup> segment and PIVA of RCA were 45.46mm and 15.1mm respectively. Coronary atherosclerosis in association with MBs has primarily been studied in the AIV. The segment proximal to the bridge frequently shows atherosclerotic plaque formation, although the tunneled segment is typically spared<sup>27, 28</sup>. In contrast to proximal and distal segments, foam cells and modified smooth muscle cells were missing in patients' tunneled segments<sup>29</sup>. Hemodynamic forces may explain atherosclerotic plaque formation at the entrance of tunneled segment. There the endothelium is flat, polygonal, polymorph indicating low shear, whereas in tunneled segment, the endothelium has a helical, spindle-shaped orientation along the course of the segment as a sign of laminar flow and high shear.<sup>29,30,31</sup> The low shear force may induce release of endothelial vasoactive agents contributing to atherosclerotic plaque formation while a high shear may have a protective role in tunneled segment<sup>32</sup>. With the use of simultaneous proximal and distal pressure recordings, Ge *et al*<sup>10</sup> identified the highest intravascular pressure just proximal to the bridge and a pressure gradient across the bridge. The likelihood of ischemia also increases with the intramyocardial depth of the tunneled segment. An increase in sympathetic drive during stress or exercise likely facilitates ischemia, because tachycardia leads to an increase of systolic-diastolic time ratio at the expense of diastolic flow. Increased contractility during stress further aggravates systolic compression<sup>7</sup>. Incidence of MBs over branches of RCA in right dominant circulations in present study was 9.5% and of LCA in left dominant circulations was 50%. In both these cases, obstruction of the dominant coronary artery due to MBs would result in widespread effects due to larger percentage of myocardium being supplied by the dominant artery. In case of obstruction of LCA due to myocardial bridging, the wider distribution of RCA in right dominant hearts may result in lesser part of myocardium suffering from an infarct. Similarly, in case of obstruction of RCA due to myocardial bridging, the wider distribution of LCA in left dominant hearts may result in lesser part of myocardium suffering from an

infarct. The present study shows that the maximum incidence of MBs in branches of LCA was seen in right dominant circulation which was 51.1%, but the incidence of the same in left dominant circulation was 50% indicating no significant difference. The maximum incidence of MBs in branches of RCA was seen in right dominant circulation only.

## CONCLUSION

1. Incidence of Myocardial bridges is significant (54%).
2. The AIV artery is the most commonly involved branch in myocardial bridging.
3. Myocardial bridges can affect the branches of right coronary artery too.
4. The dominance of the heart has no significant correlation with occurrence of MBs.

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