

# Immediate Outcome of Coronary Angioplasty in Chronic Total Occlusions with Bridging Collateral Vessels

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## Abstract

**Background-** In angioplasty of chronic total occlusion, categorizing lesion characteristics may be useful for their impact on procedural success. There is controversy about the role of bridging collateral vessels in chronic total occlusion procedural outcomes. This study investigated the effect of bridging collateral vessels on the success of coronary angioplasty in patients with chronic total occlusions.

**Methods-** Seventy-seven consecutive patients undergoing coronary angioplasty for chronic total occlusion were classified into two groups. Group I patients had chronic total occlusion with bridging collateral vessels (27 patients), and patients in group II had no such vessels (50 patients).

**Results-** Procedural success was achieved in 11 patients in group I and in 41 patients in Group II (40.7% vs. 82%;  $p=0.0002$ ; relative risk 3.9; 95% confidence interval 1.7 - 6.4). Of 52 patients with successful angioplasty, patients with an estimated duration of occlusion of less than 3 months had more successful results than patients with occlusions of over 3 months (63.5% vs. 47.5%;  $p=0.0001$ ; relative risk 1.8; 95% confidence interval 1.3-2.6). The presence of a side branch 2mm or less from the occlusion point was a predictor of an unsuccessful result ( $p=0.0007$ ; relative risk 2.9; 95% confidence interval 1.5-5.6).

**Conclusion-** There are some morphologic variables which may be useful in guiding angioplasty in patients with chronic total coronary occlusion. Presence of bridging collateral vessels is one of them, which appears to be inversely related to procedural success (*Iranian Heart Journal 2003; 4 (4):16-21*).

**Key Words:** Angioplasty ■ Coronary occlusion ■ Collateral circulation

Chronic coronary occlusions account for 10% to 20% of coronary angioplasty procedures in most centers.<sup>1,2</sup> Chronic total coronary occlusion (CTO) remains a major problem for percutaneous revascularization, with relatively low primary success rate and higher cost, fluoroscopy time and equipment use than percutaneous transluminal coronary angioplasty (PTCA) of high-grade stenosis.<sup>3-6</sup>

Recanalization of chronic coronary occlusions by PTCA has been reported to have a primary success rate of 54% to 81%.<sup>7-10</sup> Technologic advances and increased operator experience have allowed successful primary recanalization of chronic total occlusions to be achieved in more than 70% and with a low risk, but with a restenosis rate of 44% to 77% of patients.<sup>7,8</sup> Coronary artery stenting has emerged as a valuable therapeutic strategy for the management of CTO.

Intracoronary insertion of the Palmaz-Schatz stent and the new, less shortening Wallstent after successful PTCA of CTO have been associated with favorable restenosis and reocclusion rates, improved anginal status and a reduced need for late coronary artery bypass graft surgery (CABG).<sup>11-13</sup> Bridging collateral vessels are well-developed vaso vasorum in CTOs. Their development appears to be proportional to the duration of occlusion. While Kinoshita et al.<sup>7</sup> reported that angioplasty can open CTOs with or without bridging collateral channels, in other reports the presence of bridging collateral vessels is a strong predictor of procedural failure.<sup>14,15</sup> The aim of the present study was to assess the relation between the presence of bridging collateral vessels in angioplasty and the procedural success.

### Methods

Between January 2001 and December 2002 coronary angioplasty was attempted in 77 patients with CTOs. To evaluate the influence of the bridging collateral channels on immediate outcome of angioplasty in CTOs, we classified the study patients into two groups. Patients in group I had CTO with bridging collateral channels (27 patients), whereas patients in group II had CTO without bridging collateral channels (50 patients). The patients having had a previous revascularization procedure or myocardial infarction within 1 month of the procedure were excluded from our study. The indication to perform angioplasty was the presence of angina or evidence of ischemia demonstrated by stress testing or thallium scintigraphy. All the patients gave written, informed consent to the procedure.

### Definitions

A CTO was defined as a complete interruption of the vessel, with either Thrombolysis in Myocardial Infarction

(TIMI) flow grade 0 (absolute occlusion) or TIMI flow grade 1 (functional occlusion) which was more than 1 month old. The duration of the occlusion was estimated from previous angiographic data or from the date of a myocardial infarction in the distribution of the occluded vessel. In the absence of these data, a worsening of anginal status was utilized to estimate the duration of the occlusion. Recorded angiographic characteristics included the morphologic features of the occlusion (abrupt vs. tapered), the presence of a side branch at a distance of less than or equal to 2 mm (vs. more than 2 mm) at the point of the occlusion and the diameter of the vessel before the occlusion point (measured by cineangiography with manual calipers).

### Angioplasty procedure

Before undergoing angioplasty, all the patients were given aspirin and ticlopidine or clopidogrel. During the procedure 10000 to 15000 U heparin was given intravenously. Total occlusion was approached with a 1.5 mm to 2 mm balloon catheter over a 0.014 inch flexible guide wire. We used BMW Hi-Torque or Boston Scientific Scimed guide wires to cross the lesion. After crossing the lesion, we performed inflation with pressures so as to achieve full balloon expansion. Then the segment was recrossed with larger balloons. Successful recanalization was defined as restoration of TIMI grade 2 or 3 flow with a residual stenosis < 50% of the lumen diameter by visual estimation. Of 52 patients with successful results, stent was implanted in 47 patients.

### Statistical Analysis

Statistical analysis was performed by using the Student t-test to compare group means and the Chi-square test for the comparison of categorical variables. Continuous variables are expressed as mean value  $\pm$  SD. A  $p$  value < 0.05 was considered

statistically significant.

**Table I: Base Line Characteristics**

	Successful (n=52)	Unsuccessful (n=25)	p value
Age(yr)	52 ± 10.5	58 ± 10.4	0.02
Male patients	47(71.2%)	19(28.8%)	NS
Prior MI	31(66%)	16(34%)	NS
Anginal class*			
0	5(71.4%)	2(28.6%)	NS
1-2	27(65.8%)	14(34.2%)	NS
3-4	20(69%)	9(31%)	NS
Duration of occlusion			
<3 months	33(89.2%)	4(10.8%)	0.0001
≥3 months	19(47.5%)	21(52.5%)	

NS=Not significant; MI=Myocardial infarction; \*Canadian Cardiovascular Society Classification

Patients in whom angioplasty was successful were younger than patients with unsuccessful angioplasty result. No major differences were noted between the two groups with respect to gender, previous myocardial infarction or anginal class. Approximately, 60% of the patients in both groups had a prior myocardial infarction. Patients in whom the duration of occlusion was estimated to be less than 3 months had a significantly more successful angioplasty result and the *p* value was 0.0001, with a relative risk of (RR) 1.9 (95% confidence interval 1.3 to 2.6).

### Angiographic characteristics

The angiographic characteristics of the study patients are shown in Table II. The number of diseased vessels was nearly similar in both groups. The target vessel considered for CTO angioplasty and left ventricular ejection fraction had no significant differences between patients with successful and unsuccessful angioplasty results. Successful recanalization was achieved in 52 (67.5%) patients. In patients with successful recanalization, only 11 (21.2%) patients had bridging collateral vessels, whereas in patients with unsuccessful recanalization 16 (64%) patients had bridging collateral vessels and the relative risk was 3.3 (*p* value was 0.0002, 95% confidence interval (CI) 1.7 to 6.4). So the presence of bridging collateral vessels was a risk factor

for unsuccessful recanalization. The diameter of the vessel proximal to the totally occluded lesion was significantly higher in patient with successful recanalization (*p* value = 0.02). Also, in our study, abrupt occlusion morphology had different results as opposed to tapered morphology, but this difference was not statistically significant. Of 52 patients with successful recanalization, only 11 (21.2%) patients had a side branch less than 2mm from the occlusion point (vs. 60% in whom angioplasty was unsuccessful) and *p* value was 0.0007 (RR=2.9, 95% CI 1.5 -5.6). As a result, the presence of a side branch less than or equal to 2 mm from the occlusion point was a risk factor for unsuccessful recanalization. Conversely, the presence of a side branch farther than 2 mm from the occlusion point was not a risk factor for unsuccessful angioplasty in CTO (RR=0.03).

**Table II. Angiographic characteristics**

	Successful n=52	Unsuccessful n=25	P value	Rel Risk
LVEF	51 ± 14	49 ± 15	NS	
<b>Diseased Vessels</b>				
One	28(66.7%)	14(33.3%)	NS	
Two	15(65.2%)	8(34.8%)	NS	
Three	9(75%)	3(25%)	NS	
<b>Occluded Vessel</b>				
LAD	31(64.6%)	17(35.4%)	NS	
RCA	15(65%)	8(35%)	NS	
LCX	3(100%)			
OM	3(100%)			
Presence of Collateral Vessels	11(40.7%)	16(59.3%)	0.0002	3.3
Diameter of Vessel	2.9 ± 0.3	2.7 ± 0.3	0.02	1.8
<b>Occlusion Morphology</b>				
Abrupt	13(54.2%)	11(45.8%)	0.09	
Tapered	39(73.6%)	14(26.4%)	0.09	
<b>Presence of Side Branch</b>				
<=2mm	11(42.3%)	15(57.7%)	0.0007	2.9
>2mm	21(87.5%)	3(12.5%)	0.01	0.3

LVEF=Left ventricular ejection fraction, NS= not significant, LAD= left anterior descending artery, RCA=right coronary artery, LCX=left circumflex artery, OM=obtuse marginal.

We had no major complications such as death, myocardial infarction, cardiac tamponade and the need for urgent bypass

surgery. We had 3 dissections in patients with successful recanalization, which were managed successfully with stent implantation. We also had 3 patients with extraluminal passage of guide wire, none of them having any deleterious results. In 21 patients of the 25 individuals, the reason for unsuccessful angioplasty result was wire cross failure of the lesion; in 3 patients angioplasty was terminated because of extravasation; and in one patient the balloon was unable to cross.

### Discussion

Recanalization of chronic total occlusion represents 10% to 20% of all angioplasty procedures.<sup>16</sup> The success rate for this procedure is 60% to 70% in most reported studies.<sup>4,17</sup> Successful angioplasty of CTO can be associated with a favorable long-term outcome.<sup>4,17</sup> It may be useful to categorize lesion characteristics for their impact on the success rate of angioplasty of CTO.

**Bridging collateral vessels:** In our study, the presence of bridging collateral vessels was a strong predictor of unsuccessful angioplasty result. A feature of all CTO angioplasty series is the infrequency of complications related to the occlusion site, such as death, infarction or need for emergency surgery.<sup>6</sup> This may be due to a protective effect of well-developed collateral flow. One histological study confirms that all vessel wall locations have extensive neovascularization<sup>18</sup> but with different histological details with respect to the age of CTO. Several investigators have reported that the presence bridging collateral vessels is the most powerful predictor of procedural failure.<sup>15,16</sup> Inoshita et al.<sup>7</sup> reported that performing coronary angioplasty of chronic total occlusions with bridging collateral vessels was feasible and their procedural success was similar in patients with and without such

vessels. They attributed their high success rate to improved equipment evolution and to refined angioplasty techniques. This discrepancy in CTO angioplasty success rate with bridging collateral vessels may be due to the duration of occlusion and the age related changes in intimal plaque composition and neovascular pattern of CTO. The adventitia and intimal plaque of total occlusions are the predominant zones of cellular inflammation and neovascularization within the arterial wall of all CTOs. The neovascularization in CTO increases with age.<sup>18</sup> Clinically, most investigators have found that the estimated duration of occlusion appears to predict the likelihood of a successful outcome.<sup>7,9</sup> However, other investigators have reported a less compelling association between the duration of occlusion and the primary angioplasty success.<sup>4,16,19</sup> Based on these reports, it seems that angioplasty may be a reasonable approach even for patients with long-standing occlusions. Also, in our study the presence of bridging collateral vessels was a predictor for an unsuccessful recanalization result in CTO. We had some limitations regarding the use of stiffer guide wires in our study, which may affect the final result since in 84% of our study patients the reason for failure to recanalize the lesion was the cross-failure of the wire. Consequently, we suggest that patients should not be excluded from attempted coronary angioplasty simply on the basis of the presence of bridging collateral vessels.

**Age of occlusion:** In our study, an estimated duration of occlusion of less than 3 months was a predictor of successful coronary angioplasty in CTO. This finding supports some other investigations.<sup>4,16</sup> One investigation did not find this variable to be significant.<sup>20</sup> Lack of uniformity and clarity in defining the duration of occlusion may be the reason for these different results.

**Tapering vs. abrupt morphology:** Our study points out that tapered occlusion morphology gave better recanalization results than abrupt morphology, but this difference was not significant. Nonetheless, several investigators have shown that tapered morphology predicts a favorable angioplasty procedure outcome as opposed to abrupt morphology.<sup>14,15,16</sup> Kereiakes et al.<sup>21</sup> did not find this variable to be significant.

**Side branch at the point of occlusion:** While a few studies have reported that the presence of a side branch at the point of occlusion is a predictor of procedural failure, most have reported a higher success rate in the absence of a side branch.<sup>1,14,15,16</sup> In our study, the presence of a side branch at a distance less than or equal to 2 mm from the occlusion point was associated with less favorable outcome, while if the distance was over 2 mm, the angioplasty result was not affected. Our study had some limitations. The total number of our study patients is relatively small because the study was performed in only one center. In our study we did not use stiffer guide wires, which explains our high rate of inability to cross the lesion. Our complication rate was low, which may be attributable to an early termination of attempted angioplasty in order to avoid complications.

### Conclusions

In CTOs, revascularization is often required for relieving angina pectoris or ischemia. Procedural success rate in these patients is generally low despite many technological advances. Some clinical and morphologic variables affect the procedural success. These variables include the presence of bridging collateral vessels, an abrupt as opposed to tapered lesion morphology, the presence of a side branch at a distance of less than 2 mm

from the occlusion site and the age of the occlusion. The impact of each of these variables and the role of the new devices necessitate further investigations.

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