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Case Report

Feasibility of Percutaneous Transluminal Coronary Angioplasty (PTCA) in Total Coronary Artery Occlusion (TCO)

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Abstract

Percutaneous transluminal coronary angioplasty, (PTCA), was attempted in twenty consecutive patients with 100% coronary occlusion, without antegrade visualization of contrast material in the occluded vessel. The time interval between coronary angiography and angioplasty was 7.8 days. Of the twenty patients that underwent angioplasty, six had unstable angina, eleven had stable angina, one had acute myocardial infarction, and two had post-infarction angina. The occluded vessel was the left anterior descending, (LAD), coronary artery in thirteen patients, the right coronary artery, (RCA), in six patients, and the left circumflex, (LCX), coronary artery in one patient.

The duration of occlusion in twenty patients had a mean of 109 days, (a range of 0-1440 days), and was estimated by the interval between myocardial infarction and initial coronary angiography. The mean gradient across the stenosis was measured before and after dilatation, 56mm before and 10mm after. The mean stenosis before PTCA was 100% and after dilatation 34%. Angioplasty was successful in 75%, (15/29), of patients and 63.5%, (5/8), of patients at a six month restudy.

Five patients were unsuccessful at angioplasty, the guidewire was unable to cross the stenosis in three patients, and the balloon catheter failed to dilate the stenoses in two patients, of which one patient underwent immediate coronary bypass surgery. The majority pf the patients, (12/20), were not restudied, however functional improvement was noted. Twenty patients were class 1.9 compared to 3.25 prior to angioplasty.

In conclusion, there is a high success rate with regard to PTCA in symptomatic patients with total occlusion of coronary artery. The procedure can be performed with slightly less success than traditional angioplasty with safety and with low mortality.

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Keywords: Percutaneous transluminal coronary angioplasty; Total coronary artery occlusion; Coronary bypass surgery; Stenosis.

Introduction

Coronary arteries are no strangers to the risks of stenosis and occlusion after years of plaque buildup as part of the new, and medically problematic, processed fast food era we are in. Progressive narrowing of vessel lumen increases risk of ischemia related complications of the body part supplied by said vessel. In the case of the coronary arteries, this represents an increasing risk of myocardial ischemia and infarctions. If the stenosis evolves into a complete 100% blockage of the coronary artery, total occlusion is achieved.

Defined as a complete blockage of one or more coronary arteries with a Thrombolysis-In-Myocardial-Infarction (TIMI) grade 0 antegrade flow for at least 3 months [1], Chronic Total Occlusions (CTO) of coronary arteries are often found on angiographies of patients experiencing different coronary syndromes as well as those with above-normal BMIs and unhealthy fat-dominant food habits. Fefer, et al. estimate that up to 20% of all patients sent for coronary angiography have CTO [2], while Christofferson and his colleagues approximate CTOs in a third to half of all patients with pre-existing coronary artery disease (CAD) [3].

In patients at a tertiary veterans' hospital in 2013, Jeroudi, et al. found that prior Coronary Artery Bypass Graft (CABG) were also associated with a higher prevalence of CTOs [4]. Similarly, Cohen et al in 2003 looked through the National Heart Lung and Blood Institute Dynamic registry between 1997 and 1999 and found CTOs to be a frequent finding in elder patients, with the incidence rising with age (36.5% in those below 65 years of age to more than 40% in those above 80 years of age). Furthermore, the Right Coronary Artery (RCA) was found to be the most common coronary vessel to have a CTO [5].

Ever since the introduction of non-operative coronary angioplasty (PTCA) by Gruntzig in 1977, PTCA has been performed on patients with single and multiple vessel coronary artery disease. The ideal candidate has an isolated proximal stenosis of a single coronary artery with less than 15mm obstruction. Most important, the patient should meet all the requirements and be considered a candidate for possible coronary artery bypass surgery if PTCA was unsuccessful. Patients with left main coronary artery disease, coronary artery spasm, patients who were not candidates for coronary artery bypass surgery, and patients with total coronary artery occlusions, should not undergo PTCA. Previous reports concerning angioplasty in total coronary artery occlusion exist however, they include patients with subtotal occlusion with lesions 90-99% range. In this investigation, twenty patients had 100% stenosis of a single coronary artery at the time of PTCA. With increasing skill on the part of the investigation performing the procedure, with new developments and techniques such a custom shaped movable guide wire system, improved pressure tolerance of low-profile

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balloon catheters, it is now feasible to perform PTCA of a total coronary artery. The technic was successful in 32 patients, reducing the stenosis from a mean of 84 to 34 percent (P<0.001) and the coronary pressure gradient from a mean of 58 to 19 mmHg (P<0.001) [6]. Similar results were also observed in relatively fewer studies of patients with unstable angina without higher rates of complications [7].

Pathophysiology

Chronic Total Occlusions are in essence a complication of atherosclerotic plaque buildup. What distinguishes it from the latter is the duration and degree of occlusion. Where atherosclerosis usually causes stenosis of the involved vessel leading to bouts of ischemic injury upon increased workload, CTOs represent 100% blockage of the vessel, characterized by TIMI grade 0 antegrade flow, rendering that vessel incapable of blood supply at all. However, CTOs by themselves do not usually "cause" ischemic injuries despite total occlusion. This is explained by their chronicity.

The chronic nature of CTOs allows the coronary artery to induce collateral vessel formation in order to bypass the need for the original artery and prevent an acute infarction when the lumen is eventually occluded completely. These collaterals take at least 2 weeks to form because of pressure mediated arterial dilation proximal to the blockage [6] and become essential to the function of the cardiac muscle formerly supplied by the effected coronary artery but lack the capabilities of increasing oxygen and blood supply during periods of strenuous activity. This is what manifests as a collection of angina symptoms clinically indistinguishable from the far more common ACS.

Furthermore, in Srivatsa and colleagues' study [8], plaque age could also be determined considering histologic composition of more cholesterol and foam cells in younger CTOs and greater calcification and fibrosis in older CTOs. Srivatsa and colleagues also noticed that 49% of lesions that showed 100% occlusion on angiography were still, in fact, 99% occluded on postmortem examination. This discrepancy in angiographic vs actual occlusion was found to be more common among younger CTOs.

Risk factors

Since the pathophysiology of a Chronic Total Occlusion is similar to that of a CAD, bar a few key differences, it is not unreasonable to predict risk factors for developing a CTO from our current knowledge about coronary artery diseases as a whole.

Pre-existing CAD or a history of atherosclerosis based ischemic heart disease is an obvious risk factor due to the similar role of plaque buildup in both ACS and CTOs. Understandably, 30 to 50% of people with pre-existing CAD can have a present CTO in their coronary arteries [9].

Unhealthy lifestyle conditions carry significant risks for heart diseases in general. Therefore, CTOs can also be expected to occur more frequently in people with uncontrolled diabetes mellitus, obesity and a

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sedentary lifestyle, untreated hypertension as well a persistent smoking habit.

On the genetic side of things, having a family history of premature CAD can also increase a person's risk for developing total coronary occlusion. Premature CAD is defined as coronary narrowing in a male relative under 55 years of age and a female relative under 65 years of age.

Patient selection

20 Consecutive patients with total coronary artery occlusion underwent percutaneous transluminal angioplasty (PTCA) after informed consent.

There were 13 male and 7 female patients with a mean age 57 years (range 41-74). All patients underwent initial coronary angiography because of angina refractory to medical therapy. Two patients had prior coronary artery bypass surgery, seven patients had prior anterior wall myocardial infarction (AWMI), 3 patients had prior inferior wall myocardial infarction (IWMI), 1 patient had acute anterior wall myocardial infarction (AAWI), and 4 patients without prior myocardial infarction.

The character of angina was described according to the Canadian Cardiovascular Society Classification. Six patients had class IV, 13 were class III, and 1 with class II angina (mean class of 3.25).

Of the 20 patients that underwent coronary angiography, 6 had unstable angina, 11 had stable angina, 1 had acute myocardial infarction, and 2 had post-infarction angina. None of the patients had documented coronary artery spasm during initial coronary angiography.

Angiographic characteristics

Twenty patients had undergone coronary angiography prior to PTCA. Twenty patients had 100% stenosis of a single coronary artery without antegrade opacification of contrast, at the time of PTCA. The occluded vessel was the left anterior descending (LAD) coronary artery in 13 patients, the right coronary artery (RCA) in these patients, the time interval between coronary angiography and PTCA was 7.8 days.

All the patients had a cardiac surgical operating room held empty with full anesthetic and surgical teams available if the patient required urgent operative intervention.

Results

Outcome of angioplasty

All 20 patients had 100% stenosis at angioplasty with no antegrade visualization on contrast material in the occluded vessel. Total occlusion of the LAD was seen in 13 patients (65%) and more common than the RCA, 6 patients (30%) and LCX, 1 patient (5%). Successful dilatation of 100% stenosis of a single coronary artery was achieved in 15 patients (75%).

Angiographic success is defined to be a decrease of at least 20% in luminal diameter narrowing, while clinical success is defined as angiographic success plus survival without M.I. or CABG during the hospitalization period. Of the 5 patients with unsuccessful angioplasty: the guidewire was unable to

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cross the stenosis in 3 patients, in 2 patients the balloon catheter failed to dilate the stenosis. The mean gradient across the stenosis was measured before and after dilatation, 56mm before and 10mm after. The mean stenosis before PTCA was 100% and after dilatation 34%. Patients demonstrated retrograde filling from collateral blood flow during initial coronary angiography.

Of these collateral flow was no longer present just after angioplasty. None of the 20 patients suffered complications such as dissection, coronary rupture, coronary artery spasm, myocardial infarction, thromboembolic events, or death as a result of angioplasty.

Results

Estimated time of occlusion

The estimated duration of occlusion in 20 patients after PTCA was a mean of 109 days with a range 0-1440 days.

Time of occlusion of 13 patients was estimated and based on the interval between myocardial infarction and initial coronary angiograms. There was no prior history of myocardial infarction in 4 patients. Their angina was considered stable and thus it was difficult to estimate the actual time of occlusion.

Two patients had subtotal occlusion of the LAD (98% and 95% respectively) at the time of initial coronary angiography. In a brief period of time, (15 days in the former and 6 days in the latter) total occlusion was demonstrated at the time of angioplasty. One patient (No.5) had acute anterior wall myocardial infarction and was sent for coronary angiography which documented 100% stenosis of the LAD.

Results

Follow up study

After PTCA, twenty patients were class 1.9, compared to 3.25 prior (Table 1). Of the twenty patients that underwent angioplasty; eight were restudied (two with early closure, one due to late closure, and five as part of elective six-month follow-up evaluation), ten underwent medical therapy, and one expired two months after angioplasty from lymphoma.

Of the two patients (16,19) with early closure at the angioplasty site (both within eight days after PTCA), both underwent a second angioplasty. The former had a successful angioplasty at another institution, and the latter underwent coronary artery bypass surgery (four months later), after unsuccessful angioplasty. Both patients were Canadian Class 2 after six months.

One patient who developed late closure of the LAD (after six months) remained class 2 on medical therapy.

The remaining five patients that were restudied based on a 6 month follow up study, all demonstrated patent PTCA sites and were class I (one patient) and class 2 (4 patients).

The ten patients on medical therapy remained class 1.9 after six months.

The patient that underwent coronary artery bypass after unsuccessful angioplasty was class II after six months.

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Pt	Age/Sex	Status	Pca	MI	Prior Tp Ptca Days	Occlusive Days	System Pca	Angiography to Ptca Days	Pt Initial Angio-graphy	Prior Angio-graphy	Mm/Hg Prior	Mm/Hg After	After Angiography	Failure At Ptca	Angiogram	Follow-Up/Functional Class
1	58 M	Stable	3	IWMI	28	28	RCA	10	100	100	60	0	100		N.O.D. at 6 mths	2
2	47 M	Unstable	3	IWMI	13	13	LCX	13	100	100			100			1
3	54 M	Stable	3	AWMI	27	22	LAD	5	100	100			100	Unable to pass wire		1 (After CABG)
4	66 F	Stable	3	No MI	21	Unkown	LAD	4	100	100	50	10	0		N.O.D. at 6 mths	2
5	74 M	STEMI	4	STEMI	Same day	Same Day	LAD	Same day	100	100			50			2
6	61 F	Unstable	4	AWMI	70	19	LAD	15	98	100	45	5	10			1
7	67 M	Unstable	3	AWMI	1095	28	LAD	6	95	100			5		Late closure at 6 mths	2
8	52 F	Unstable	4		100	90	LAD	Same Day	100	100	60	30	50		N.O.D. at 6 mths	3
9	54 M	Post Infarction	4	ASMI	20	20	RCA	Same Day	100	100			100	Unable to pass wire		1
10	74 F	Stable	3	STEMI	120	100	LAD	3	100	100	50	0	0		N.O.D. at 6 mths	1
11	62 M	Post Infarction	3	AWMI	30	30	LAD	14	100	100	60	10	20			2
12	46 M	Stable	3	AWMI	255	255	LAD	10	100	100	50	0	0		N.O.D. At 6 mths	2
13	44 M	Unstable	2	STEMI	42	24	RCA	24	100	100	50	0	30			2
14	73 F	Stable	3	No MI	1095	Unknown	RCA	5	100	100			100	Unable to infiltrate balloon		4
15	41 M	Stable	3	STEMI	365	7	LAD	1	100	100			0			1
16	62 F	Stable	4	IWMI	365	21	RCA	5	100	100	15	15	0		Early Closure 8 Days	2 (After Repeat PTCA)
17	58 M	Stable	3	No MI	Unknown	Unknown	LAD	Same Day	100	100	65	10	10			1
18	57 M	Stable	3	No MI	3650	Unknown	LAD	12	100	100			90			2 (Expired After 2 Mths Secondary to Lymphoma)
19	55 M	Unstable	4	AWMI	1440	1440	RCA	15	100	100			50		Early Closure 8 Days	2 (After CABG)
20	64 F	Unstable	3	AWMI	35	30	LAD	7	100	100			100	Unable To Pass Wire		3

Table 1: Follow up study of the patients.

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Percutaneous Coronary Intervention (PCI)

PCI is quickly becoming the go-to treatment for CADs. Naturally, TCOs also benefit from PCI, but compared to a subtotal occlusion where there is space for the catheter to move and place the stent, the totality of the occlusion presents several challenges and potential complications of the procedure and is not recommend.

Complications include and are not limited:

- The inability of the guidewire to cross through the lesion,
- The danger of guidewire penetrating the intimal walls during occlusion clearance step or failure to reach the distal lumen,
- Failure to pass a balloon after guidewire into the lesion,
- Failure in sufficiently expanding the stent and dilating the lumen owing to calcification and fibrosis and,
- Perforation of the vessel itself.

CTO-PCI outcome can be predicted with scoring systems such as the E-CTO score developed by Mohandes, et al. [10], the J-CTO score [11], and the PROGRESS-CTO score [12]

Conclusion

The ability to choose patients to obtain a successful outcome at angioplasty depends upon the patient selection, characteristics of coronary anatomy and more so the experience of the investigator. There is a high success rate with regard to PTCA in total coronary anatomy occlusion (TCO). The procedure can be performed with slightly less success than conventional PTCA. The success of conventional angioplasty has reached 91%.

The success of PTCA in TCO has been reported at 54% in two studies. It was reported that angioplasty in TCO was more successful (68%) if performed in patients with occlusion less than 12 weeks duration. A similar result was seen in our investigation, 15/20 (75%) patients had initial success at angioplasty and 5/8 (63.5%) success at a six-month follow-up angiography.

Emergency coronary artery bypass surgery has remained at 5%. We reported similar results for 5% (1/20) of the patients. The safety of angioplasty is far greater than coronary artery bypass surgery. Recent mortality statistics report 0.17% deaths in 3000 consecutive patients during conventional angioplasty and 6% with TCO during acute myocardial infarction.

In this investigation, death was not associated with angioplasty. Re-occlusion after angioplasty in TCO has been reported 29% and occurred early and is associated with chest pain. In our investigation, restenosis occurred in 37.5% (3/8 patients).

Two patients had chest pain and early closure eight days after angioplasty; one patient was asymptomatic and found to have late closure within 6 months.

Although the majority of patients were not restudied, functional improvement was noted. Twenty patients were class 1.9 compared to 3.25 prior to angioplasty.

Data has been collected from 34 centers in the United States and Europe performing

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percutaneous transluminal coronary angioplasty since September of 1977 [13].

As with all sophisticated techniques, operators who preform PTCA show a learning curve [14].

PTCA can be performed in patients with symptomatic coronary artery disease and TCO. There is a high initial success rate, and the procedure can be performed with safety and with a low morbidity and mortality.

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