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RETROGRADE VERSUS ANTEGRADE PERCUTANEOUS CORONARY INTERVENTION OF PATIENTS WITH CHRONIC TOTAL OCCLUSION OF THE CORONARY ARTERIES BY USING CORONARY ANGIOGRAPHY

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ABSTRACT

Chronic total occlusion (CTO) of coronary arteries is one of the most challenging percutaneous coronary intervention (PCI), usually defined as more than three-month-old obstruction of a native coronary artery(CA). Only 7-15% of CTOs were treated with PCI. Despite these obstacles, several studies have documented that successful PCI of CTOs leads to an improvement in anginal status, normalization of functional tests, improvement of left ventricular (LV) functions and avoidance of coronary artery bypass graft surgery (CABG). Nowadays, specifically trained operators are able to improve the rate of CTO recanalization thanks to several new techniques and dedicated device developments. In particular, the retrograde CTO PCI approach that was first mastered by Japanese operators has evolved rapidly, resulting in higher success rates, shortened procedural time and reduced exposure to radiation. ***Aim of the study:*** *to evaluate the Differences between the Antegrade and Retrograde PCI in the patients with CTO of the coronary arteries in the success rate, TIMI grade flow, procedural characteristics, angiographic characteristics, and complication, by Coronary Angiography.* ***Patients and methods****: The study was conducted through the period from October 2010 to May 2013and included 30 patients, 30 (100 %) males with age from 40 to 67 years old. CTO lesions were treated with help from expert interventional cardiologist, Japanese expert at kopri elkopa military hospitals.* ***Inclusion criteria:*** *30 Patients have chronic total occlusion of their coronary arteries* ***Exclusion criteria:*** *- Patients with end stage renal disease. - Patients with end stage liver disease. - Heamodynamicaly unstable patients. - Patients with acute coronary syndrome. - Patients with decompensated heart failure.*

The following was done for all patients:- 1- Patient informed consent: 2-Full history taking 3-Complete clinical examination 4-Resting surface 12 leads ECG, 5-total laboratory investigation 6- transthoracic echocardiography 7-Coronary angiography Results *This is the first reported series in which the retrograde angioplasty to the CTO arteries was compared to the traditional antegrade angioplasty to the CTO arteries. The success rate in this series was (93 %) in the retrograde approach and (67%) for the antegrade approach with no serious complication. Inability of the guide wire crossing is the main reason of the procedural failure in CTO recanalization. Several attempts have been made recently to improve the recanalization rates by novel techniques. Retrograde use of the CC and approaching the CTO segment in the retrograde fashion has resulted in some success in a selected group of patients. The common reason for failed procedure during retrograde approach in both these studies was inability to cross the collaterals because of severe tortuosity and failure to deliver the balloon through the CC. The success rates of CTO recanalization has increased from 90% to 95% with the use of retrograde methods and further increased to 97% with the application of IVUS guided reverse CART in the hands of experienced operators with accumulated experience, the operator primarily applies retrograde techniques in 50% to 60% of all CTO cases, mainly difficult or failed antegrade attempts. Recently, reverse CART with IVUS guidance was applied in 60% of the retrograde cases and conventional CART in 5% of cases with retrograde wire crossing in remaining 35% of cases. In our series, the polymer-coated wires have crossed the Coronary Collaterals (CC) successfully in all the cases. However, in two-thirds of the patients, the stiff guide wires were needed to negotiate through the CTO segment, and they were exchanged for the soft wires at the earliest opportunity. The channel dilator was successfully used in 27 cases and was not needed in 2 patients as the wire crossing through the epicardial CC was easy. In the remaining 1 case it was difficult to pass the channel dilator because of severe bending inside the CC and the* *small (1.3 mm) balloon was used to provide backup support. Reverse CART was applied to a majority of the patients, except 2 patients in whom the antegrade balloon could not be delivered to the CTO segment because of severe tortuosity. In some cases following the crossing of the CTO segment, it was difficult to negotiate the guide wire into the guide catheter. A snare wire was used in these cases to assist the procedure. With the use of septal collaterals, the collateral perforation could be seen in 5% to 10% of patients. The majorities of septal channel perforations are benign and require abandoning that channel and trying other channel. The channel dilator is safer than a balloon and rarely causes CC dissection or perforation, especially in channels with excessive beds and tortuosity. The majority of channel injury patients do not need any further treatment. In some cases, coil embolization may be required.* ***Conclusion****: Retrograde procedure is a promising option for complex CTO lesions; especially long RCA CTOs. This technique requires years of experience in the field of treating CTO, including sophisticated wire handling and conventional antegrade techniques. The operators should not be encouraged to adopt the retrograde techniques unless they have reached a certain level of expertise. Despite all recent modifications in the retrograde approach, there is still limited retrograde access in patients with CTO lesions. The atrial, epicardial, septal, and posterolateral channels are present in 60% of all CTO lesions. Predominantly retrograde techniques are dependent on creating subintimal connection and many operators hesitate to create subintimal dissection due to the risk of vessel rupture and spiral dissection. There is also potential of causing myocardial ischemia in the event of collateral injury. Although, this is seen rarely in experienced hands.*

KEYWORDS: *coronary artery disease, percutaneous coronary interventions, antegrade, retrograde, echo, tissue Doppler, LV function assessment.*

INTRODUCTION

CTO of coronary arteries is one of the most challenging PCI, usually defined as more than 3-month-old obstruction of a native CA. This coronary lesion subset is a frequent finding in patients with CAD as CTOs have been reported in approximately one-third of patients undergoing diagnostic coronary angiography. However only 7-15% of CTOs were treated with PCI,[1] Perhaps for the fact that procedural success is hampered by the difficulties associated with crossing and/or dilating the occluded segment with guide wires and recanalization devices and by a high incidence of restenosis and reocclusion. Despite these obstacles, several studies have documented that successful PCI of CTOs leads to an improvement in anginal status, normalization of functional tests, improvement of LV function and avoidance of CABG.[2] Patients with untreated CTOs face a threefold increase in cardiac mortality or complications in case of future acute events,[3] Historically, a procedural success rate of 60-70% was achieved using ante grade approach.[4] Nowadays, specifically trained operators are able to improve the rate of CTO recanalization thanks to several new techniques and dedicated device developments. In particular, the retrograde CTO PCI approach that was first mastered by Japanese operators has evolved rapidly, resulting in higher success rates, shortened procedural time and reduced exposure to radiation.[5] It should keep in mind that reopening of a CTO needs to be carefully considered in the presence of symptoms or objective evidence of viability/ischemia in the territory of the occluded artery. (***3***)**. Aim of the study:** To evaluate the Differences between the Antegrade and Retrograde PCI in the patients with CTO of the coronary arteries in the success rate, TIMI grade flow, procedural characteristics, angiographic characteristics, complication, by Coronary Angiography **Patients and methods**: The study was conducted through the period from October 2010 to May 2013 and included 30 patients, 30 (100%) males with age from 40 to 67 years old. CTO lesions were treated with help from expert interventional cardiologist, Japanese expert at kopry elkopa military hospitals. **Inclusion criteria:** 30 Patients have chronic total occlusion of their coronary arteries. **Exclusion criteria:** - Patients with end stage renal disease. - Patients with end stage liver disease. - Heamodynamicaly unstable patients. - Patients with acute coronary syndrome. - Patients with decompensated heart failure. **Helper expert**: Satoru Sumitsuji MD. FACC. **-**Director of Heart Center, Japanese expert Nozaki and Nagoya Tokushukai Hospitals **The following was done for all patients:- 1-Patient informed consent: 2-Full history taking 3-Complete clinical examination**: general and local examinations. **4-Resting surface 12 leads electrocardiography (ECG)**, in supine position by Cardiomax Fukuda Denshi model FX 7102. **5-total laboratory investigation** especially renal and hepatic functions**,** AIDs and hepatitis markers, fasting and postprandial blood sugar**. 6- transthoracic echocardiography** used VIVID 7 dimensions echo system GE. **7-Coronary angiography:** The patient undergoing to do coronary angiography to assess site of the CTO coronary arteries then the 30 lesions (30 patients) were included in the current study At the discretion of the operator, Japanese expert saturo **patients divided into two group** 1- **group A** (15 patients) treated via the antegrade approach. 2- **Group B** (15 patients) treated via the retrograde approach. **Indications for the retrograde approach** 1) Occlusion length ± 20 mm (visual evaluation), 2) Visible continuous collaterals, 3) Healthy collateral supplying vessel and 4) reattempt after previous CTO PCI failure. **Then** a- in-hospital success rate**,** b- Thrombolysis in myocardial infarction TIMI grade flow, c- Patient characteristics, d- Angiographic characteristics, e-procedural characteristics and f- procedural complications.

Were compared
Technical success was defined as restoration of antegrade TIMI flow grade 3 and final residual stenosis of less than 30%.

Collateral channels were graded as: 1-CC0= no continuous connection between donor and recipient vessel; 2- CC1 =continuous threadlike connection; and 3- CC2= continuous small side branchlike connection.[6]

Statistical analysis
Number and percentage (from quantitative data).

Analytic statistics: “T” test to compare more than two groups.

Conclusion matrix -P-value = level of significance -P > 0.05 = not significant**,** -P < 0.05 = significant, and -P < 0.001= highly significant.

RESULTS
The study was conducted through the period from October 2010 to May 2013 and included 30 patients, (100%) males, with age from 40 to 67 years old with mean age 55.92. CTO lesions were treated by at kopri elkoba military hospital in the presence of expert in retrograde PCI.

The selected patient subdivided into 2 groups
Group 1: patient treated by ante grade approach
Group 2: patients treated by retrograde approach

Table (1) shows Distribution of general characteristics between studied groups

Variable	Ante group 15)	Retro group (15)	P value
Males	15(100%)	15(100%)	1.00
Age, yrs	62+10	60+11	0.06
Body mass index _25 kg/m2	8 (53%)	5(33%)	0.006
Hypertension	12(80%)	13(87%)	0.085
Hyperlipidemia	6(40%)	10 (67%)	0.001
Diabetes mellitus	10 (67%)	9 (60%)	0.362
Cigarette smoking	11(73%)	11(73%)	1.00

Group I: 15 patients with mean age 62±10 years ranging between 38 and 75 years. 15 males 10 patients, (67%) diabetics, 12 patients (80%) hypertensive, 6 patients (40%) Hyperlipidemic and 11patients (73%) are smoking.
Group II: 15 patients with mean age 62±11 years ranging between 40 and 77 years. all males, 10 patients (67%) diabetics, 13 patients (87%) Hypertensive 10patients (67%) Hyperlipidemic and 11 patients (73%) are smoking.

Comparison between two groups as regard to risk factors
Group I: there was 12 patients) 80(% hypertensive, 6 patients (40%) hyperlipidaemic, 10 patients (67%) diabetic. **Group II:** there was 13 patients (87%) hypertensive, 10 patients (67%) hyperlipidaemic and 9 patients (60%) diabetic. Significant difference was detected between the two groups**. (P value = 0.001).**

Table(2) shows rate of success and TIMI grade flow

Characteristics	Ante group 15)	Retro group (15)	P value
Rate of success	10 (67%)	14 (93%)	0.006
Grade of TIMI flow			
TIMI 0	5 (33%)	1(6%)	0.001
TIMI 1	0	0	-
TIMI 2	0	0	-
TIMI 3	10	14	0.006

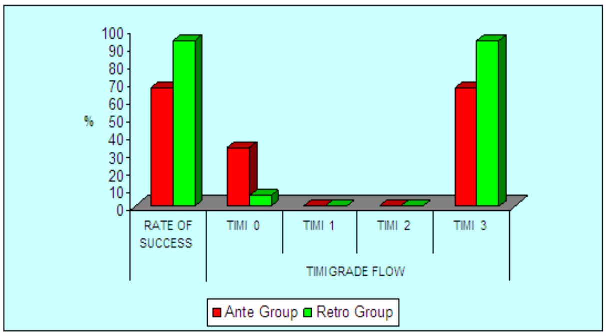

Figure (2): shows comparison between two groups as regard to success rate and TIMI grade flow

Comparison between two groups as regard to success rate
Group I: there was success rate in 10 patients (67%) in the ante grade group. **Group II:** there was success ate in 14patients (93%) in the retrograde group. Significant difference was detected between the two groups, **(P value = 0.006).**

Comparison between two groups as regard to TIMI grade flow
Group I: there was TIMI grade flow III in 10 patients (67%) in the antegrade group and 5 patients (33%) TIMI flow 0 **Group II:** there was TIMI III flow in 14 patients

(93%) in the retrograde group and 1 patient (6%) TIMI flow 0 Significant deference was detected between the two groups **(P value = 0.001).**

Table 3 shows angiographic characteristics

Angiographic Characteristics *n* (%)	Antegrade n=15	Retrograde n =15	p Value
Vessel coronary disease			
1-vessel	**2 (13%)**	**1(6%)**	**0.001**
2-vessel	**1 (6%)**	**3 (20%)**	**0.001**
3-vessel	**3 (20%)**	**5 (33%)**	**0.008**
CTO target vessel			
Right coronary artery	**5 (33%)**	**7 (47%)**	**0.025**
Left anterior descending artery	**4 (27%)**	**6 (40%)**	**0.007**
Left circumflex coronary artery	**1(6%)**	**2(13%)**	**0.001**
Left main coronary artery	**2(13%)**	**1(6%)**	**0.001**
SVG			
3- SVG	**2(13%)**	**3 (20%)**	**0.001**
1- SVG	**2(13%)**	**3 (20%)**	**0.001**
Stump morphology			
Tapered	**4 (27%)**	**5(33%)**	**0.005**
Blunt	**3 (20%)**	**6 (40%)**	**0.002**
Side branch/bridging at level of occlusions	**6 (40%)**	**9(60%)**	**0.002**
Proximal vessel segment tortuosity	**4 (27%)**	**3 (20%)**	**0.017**
Calcification	**7 (47%)**	**9 (60%)**	**0.008**
Ostial location of occlusions	**3 (20%)**	**7(47%)**	**0.001**
Occlusion length (mm)	**29.4±12.0**	**39.4±10.0**	**0.012**
Collateral connection (CC) grade			
CC0	**1(6%)**	**3 (20%)**	**0.001**
CC1	**3(20%)**	**9(60%)**	**0.001**
CC2	**11(73%)**	**13(87%)**	**0.027**

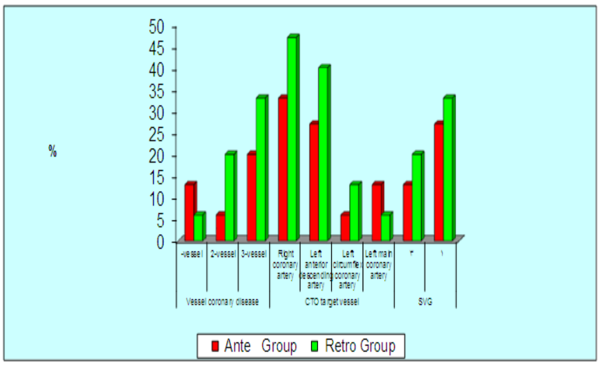

Figure (3): shows comparison between two groups as regard vessels coronary disease CTO target vessels and SVG.

Comparison between two groups as regard TO target vessles

RCA: it was lower in G1 5 patients (33%) compared to G2 7patients (47%) **(P value = 0.025). LCX:** it was lower in G1 1 patient (6%) compared to G2 2patients (13%) **(P value = 0.001). LAD:** it was lower in G1 4patients (27%) compared to G2 6patients (40%) **(P value = 0.007). LM:** it was higher in G1 2patients (13%) compared to G2 1patient (6%) **(P value = 0.001).**

Comparison between two groups as regard to vessels disease

1-One vessel disease: it was higher in G1 2patients (13%) compared to G2 1patients (6%) **(P value = 0.001). 2-Two vessels disease:** it was lower in G1 1patients (6%) compared to G2 3patients (20%) **(P value = 0.001). 3-Multivessels disease:** it was lower in G1 3patients (20%) compared to G2 5 patients (33%) **(P value = 0.008).**

Comparison between two groups as regard to saphenous venous graft

1-3- SVG: it was lower in G1 2patients (13%) compared to G2 3 patients (20%) **(P value = 0.001). 2-1-SVG** it was lower in G1 2patients (13%) compared to G2 3patients (20%) **(P value = 0.002).**

Comparison between two groups as regard to TOC stump morphology

1-**tapred**: it was lower in G1 4 patients (27%) compared to G2 5 patients (33%) **(P value = 0.002).** 2- **Blunt**: it was lower in G1 3 patients (20%) compared to G2 6 patients (40%) **(P value = 0.005). 3-Side branch/bridging** at level of occlusions: it was lower in G1 6patients (20%) compared to G2 9 patients (60%) **(P value = 0.002). 4-Proximal vessel segment tortuosity:** it was higher in G1 4patients (27%) compared to G2

3patients (20%) **(P value = 0.017). 5-Ostial location of occlusions:** it was lower in G1 3patients (20%) compared to G2 7patients (47%) **(P value = 0.001). 6-Moderate or severe calcification**: it was lower in G1 7patients (47%) compared to G2 9 patients (60%) **(P value = 0.008). 7-The mean length of the occluded segment:** it was lower in G1 29.4±12.0 mm compared to G2 39.4±10.0 **(P value = 0.012).**

Comparison between two groups as regard to collateral channel used

1-CCO: it was lower in G1 1patients (6%) compared to G2 3patients (20%) **(P value = 0.001). 2-CC1:** it was lower in G1 3patients (20%) compared to G2 9patients (60%) **(P value = 0.001). 3-CC2:** it was lower in G1 11patients (73%) compared to G2 13patients (87%) **(P value = 0.027).**

Comparison between two groups as regard to Collateral channels used

1-Septal CCs: it was lower in G1 no patient (0%) compared to G2 13patients(87%) **(P value = 0.001). 2-epicardial channel**: it was lower in G1 no patient(0%) compared to G2 2patients(13%) **(P value = 0.001).**

Comparison between two groups as regard to Guide wire selection

Soft polymer-coated guide wires were used in most of the patients to cross the CC **1- Run through**: it was lower in G1 1patient (6%) compared to G2 7patients (47%) **(P value = 0.001). 2- Fielder**: it was lower in G1 3patients (20%) compared to G2 5patients (33%) **(P value = 0.009). 3- Fielder FC:** it was lower in G1 2 patients(13%) compared to G2 4patients (27%) **(P value = 0.003). 4- Fielder X-Treme:** it was lower in G1 1patient (6%) compared to G2 2patients (20%) **(P value = 0.001).**

Comparison between two groups as regard to CTO retrograde and antegrade crossin wire

The CTO segment was crossed with a soft wire in 20% of cases and in the remaining cases, stiffer wires are used as **1- Runthrough**: it was lower in G1 1patients (6%) compared to G2 7patients (47%) **(P value = 0.003). 2-Whisper**: it was lower in G1 2patients (13%) compared to G2 3patients (20%) **(P value = 0.015). 3 -Fielder**: it was higher in G1 3patients (20%) compared to G2 1patients (6%) **(P value = 0.001). 4 -Fielder FC:** it was lower in G1 1patients (6%) compared to G2 4patients (27%) **(P value = 0.001).**

Table - 4- shows Procedural characteristics

Characteristics *n* (%)	Antegrade n=15	Retrograde n=15	p value
Collateral accessed Septal	0	13(87%)	0.001
Epicardial	0	2 (13%)	0.001
Collateral crossing wire			
Run through	1(6%)	7(47%)	0.001
Fielder	3 (20%)	5 (33%)	0.009
Fielder FC	2(13%)	4 (27%)	0.003
Fielder XT 1	1(6%)	2(20%)	0.001
CTO retrograde and antegradecrossing wire			
Runthrough	1(6%)	7(47%)	0.003
Whisper	2 (13%)	3 (20%)	0.015
Fielder	3(20%)	1(6%)	0.001
Fielder FC	1(6%)	4(27%)	0.001
Fielder XT	4(27%)	1(6%)	0.001
Crosswire NT	1(6%)	10 (67%)	0.001
Miracle	1(6%)	2(13%)	0.001
Conquest Pro	2(13%)	3(20%)	0.018
Corsair utilized	2(13%)	4(27%)	0.001
Tornus utilized	0	3(20%)	0.001
Mean contrast volume consumption (ml)	390.5±193.4	647.6±219.2	0.001

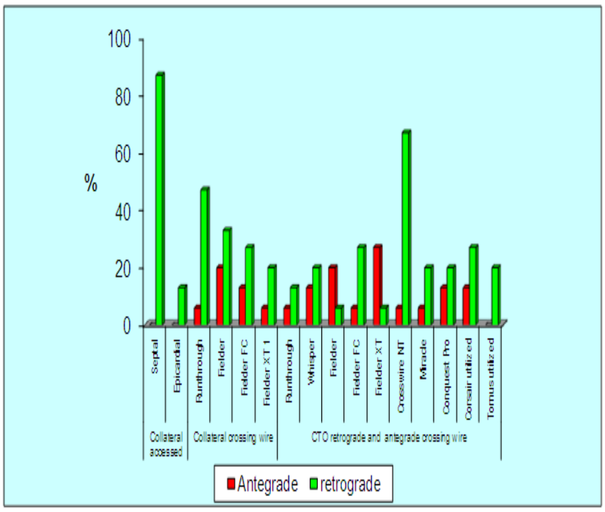

Figure (4): shows comparison between two groups as regard to collateral accessed, collateral crossing wire, CTO retrograde and antegrade crossing wire

5 -Fielder XT: it was lower in G1 4patients (27%) compared to G2 1patients (6%) **(P value = 0.001). 6- Crosswire NT**: it was lower in G1 1patients (6%) compared to G2 10 patients (67%) **(P value = 0.001). 7- Miracle:** it was lower in G1 1patients (6%) compared to G2 6patients (13%) **(P value = 0.012). 8- Conquest Pro**: it was lower in G1 2patients (13%) compared to G2 3patients (20%) **(P value = 0.018). 9 -Corsair utilized**: it was lower in G1 2patients (13%) compared to G2 4patients (27%) **(P value = 0.001). 10 -Tornus utilized**: it was lower in G1 no patients (0) compared to G2 3patients (20%) **(P value = 0.001).**

Comparison between two groups as regard Mean contrast volume consumption (ml)

Group I: Mean contrast volume consumption (ml) was 390.5±193.4

Group II: Mean contrast volume consumption (ml) was 647.6±219.2 Significant difference was detected between the two groups **(p value = 0.001).**

Table -5-shows Procedural complications and in hospital outcomes

Characteristics n (%)	Antegrade n=15	Retrograde n=15	P value
Procedural complication			
Collateral dissection	**0**	**2 (13%)**	**0.001**
Collateral perforation	**1(6%)**	**2 (13%)**	**0.052**
Tamponade	**0**	**0**	**-**
Non-target vessel thrombosis	**1 (6%)**	**1(6%)**	**1.00**
Dissection of donor vessel	**1 (6%)**	**2 (13%)**	**0.001**
Wire or devices entrapment	**2 (13%)**	**3 (20%)**	**0.063**
Stent thrombosis	**1 (13%)**	**1(13%)**	**1.00**
In-hosptial MACE	**0**	**1 (6%)**	**0.001**
Myocardial infarction	**0**	**0**	**-**
Death	**0**	**0**	**-**
TVR	**12 (80%)**	**14 (93%)**	**0.038**

All non-Q wave myocardial infarction. MACE: major adverse cardiac events; TVR: target vessel revascularization

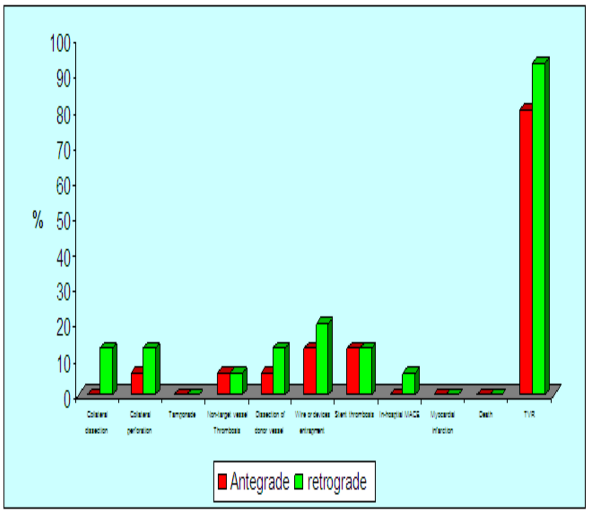

Figure (5): shows comparison between two groups according to complication

Comparison between two groups as regard complications

1- Collateral dissection: it was lower in G1 no patients (0%) compared to G2 2 patients (13%) **(P value = 0.001). 2-Collateral perforation:** it was lower in G1 1patients (6%) compared to G2 2patients (13%) **(P value = 0.015). 3- Non-target vessel thrombosis:** it was equal in G1 1patient (6%) compared to G2 1patient (6%) **(P value = 1.0). 4- Dissection of donor vessel:** it was lower in G1 1patients (6%) compared to G2 2patients (13%) **(P value = 0.001). 5- Wire or devices entrapment:** it was lower in G1 2patients (13%) compared to G2 3patients (20%) **(P value = 0.063). 6- Stent thrombosis:** it was equal in both groups 1patient (13%) for each. **(P value = 1.00). 7- In-hospital MACE:** it was lower in G1 no patients (0%) compared to G2 1patient (6%) **(P value = 0.001). 8- TVR:** it was lower in G1 12patients (80%) compared to G2 14patients (93%) **(P value = 0.038). 9- Tamponade, myocardial infarction, death** no in both groups.

Selected cases

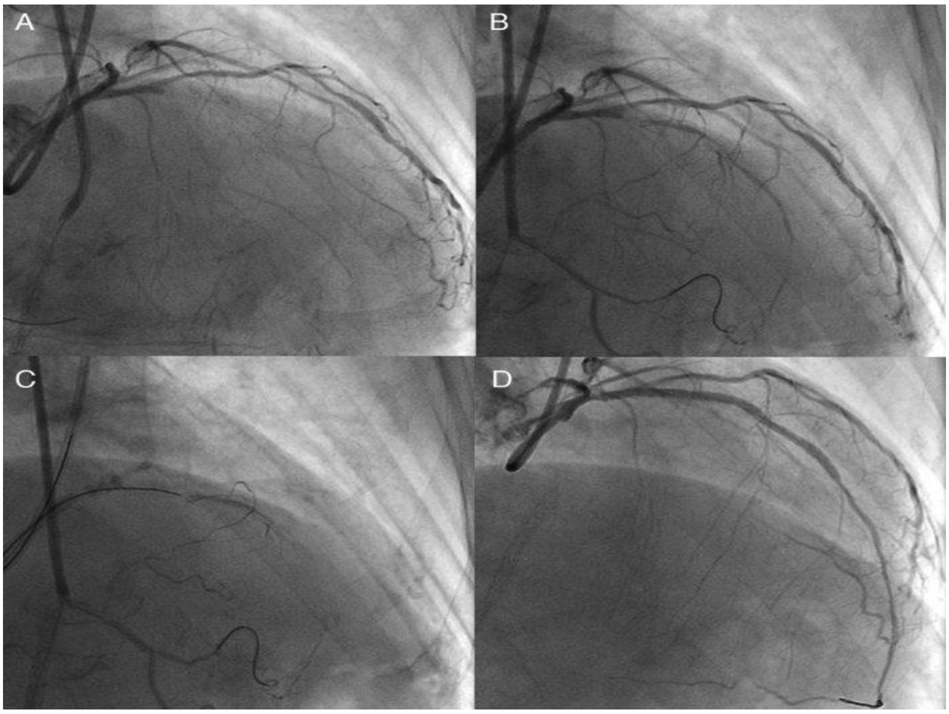

Figure -6- shows- (A). Initial angiogram missed the conus-to-septal collaterals, and therefore overestimated the characteristics of CTO LAD (B); Actuarial length of occlusion was not long on more detailed dual injection (C-D) successful wire crossing and recanalization was achieved with a Miracle Bros 3g and drug-eluting stent implantation, respectively.

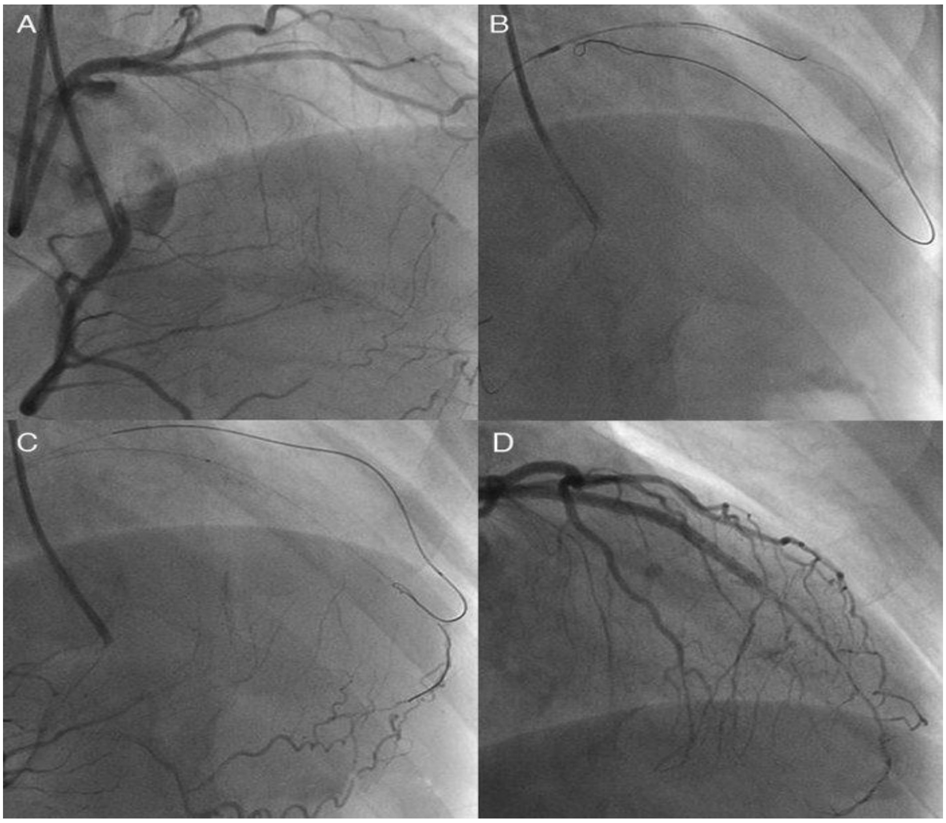

Figure (7) Shows Knuckle wire technique, In case of LAD CTO, (A), retrograde wire is advanced with a looped wire tip pushed deeper into the occlusion (B) to facilitate antegrade wire advancement for creating subintimal dissection (C), resulting in successful recanalization (D). The technique is, however, usually hampered by an uncontrollable degree of dissection and a possibility of shearing off the side branches.

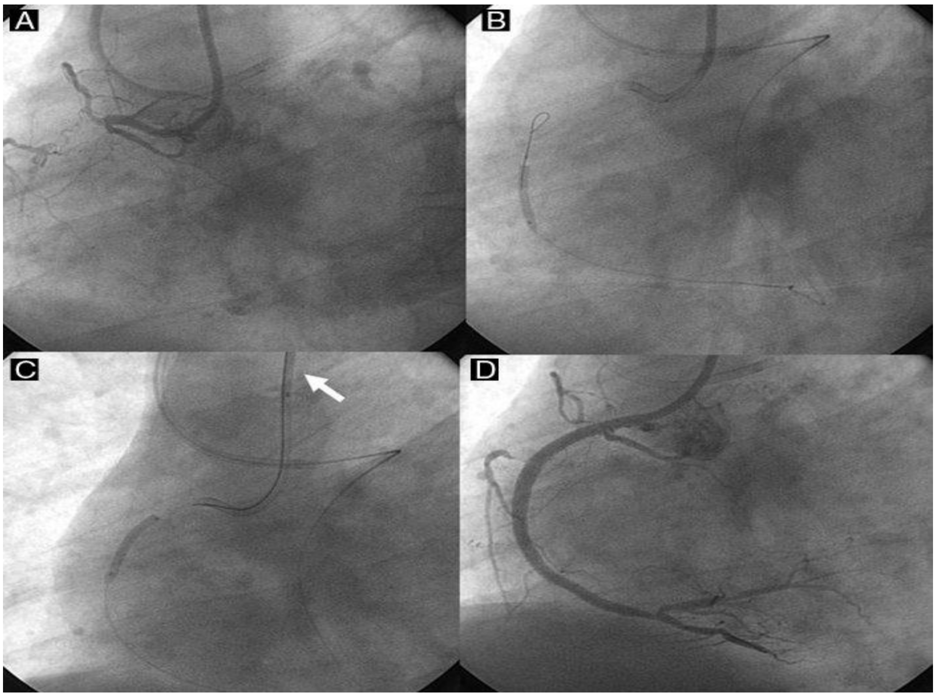

Figure (8). Shows Direct retrograde wire crossing. A retrograde wire, supported by an over-the-wire balloon (A and B), could cross a coronary CTO into the proximal vascular lumen, (and eventually) into the antegrade guide catheter (retrograde wire tip indicated by white arrow) (C). Over this wire, a retrograde balloon could dilate the CTO of the RCA and complete the procedure with antegrade wiring and stent deployment (D).

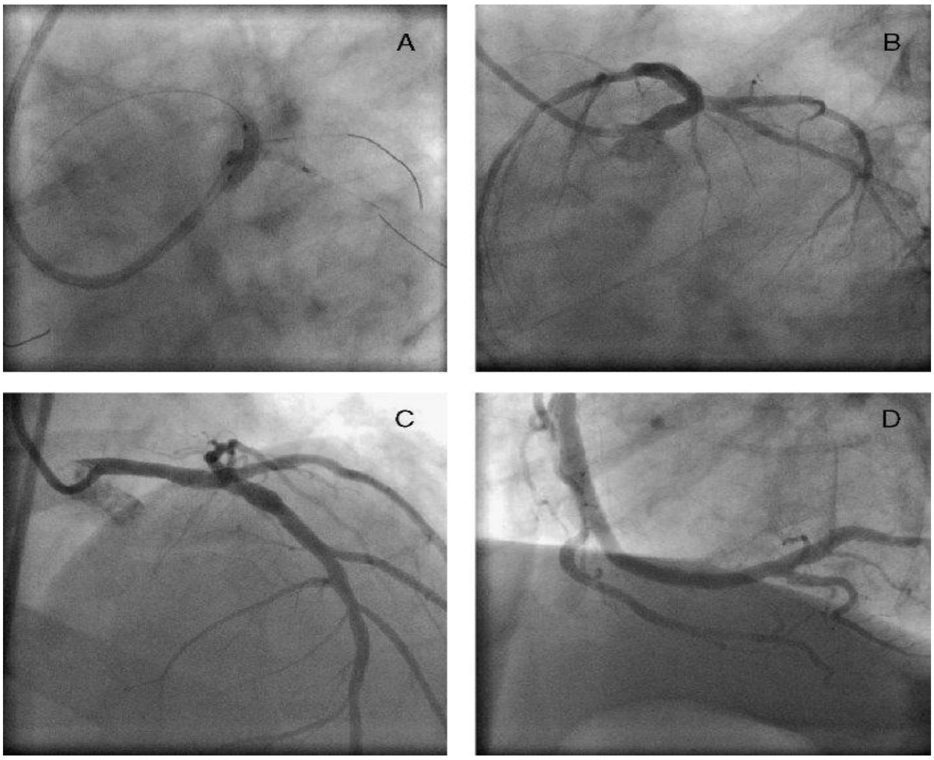

Figure (9) shows A: PCI for Left main (LM). B and C: LM after PCI. D: RCA after PCI

DISCUSSION

Older occlusions, greater CTO length, a non tapered stump, origin of a side branch at the occlusion site, and calcification negatively affect the ability to successfully cross a CTO.[7] A consensus document reported that procedural success rates dropped from 60% to 70% in the presence of 1 or more these unfavorable predictors.

Katsuragawa et al. reported a small recanalized lumen surrounded by loose fibrous tissue within the CTO segment in tapering-origin, but not in abrupt-origin occlusions that were also frequently located just distal to a side branch.[8] **Fujii et al**. demonstrated that CTO calcium was mainly located opposite the side branch take-off. This explained the difficulty with the antegrade guide wire approach in abrupt-origin type CTO origins; the guide wire often preferentially entered the side branch.[9] Autopsy studies[10] demonstrated neovascular microchannels within CTO lesions some extending from the proximal to the distal lumen, but others leading to small side branches or vasa vasorum in the vessel wall. When the antegrade guide wire entered a channel that extended to vasa vasorum, a subintimal false lumen was formed. It is unlikely that a retrograde guide wire will enter a microchannel originating from the proximal lumen. With the antegrade approach the proximal and distal fibrous caps act as barriers forcing the guide wire to enter the subintimal space.[11] The proximal cap of CTO lesions is believed to be harder than the distal cap[12],[13] **Rathore et al**. recently showed that conventional unfavorable predictors for successful antegrade CTO recanalization such as greater occlusion length did not have any significant impact on procedural success of retrograde CTO recanalization. Thus, indications for the retrograde approach would include longer lesion length, developed collaterals with a healthy donor vessel, and reattempt at recanalization. Conversely, a relatively short CTO with tortuous and discontinuous or epicardial collaterals would be preferentially managed with the antegrade approach.[14] **Surmely et al.** described successful usage of septal CCs for the retrograde approach and described successful crossing in 90% of the patients and successful dilation in 81% of the patients. They have reported low complication rates. Again, the same group described the CART technique with high success and low complication rates in a select group of patients.[15] **Sheiban et al.** described retrograde approach in 18 cases and reported success rates in 67% of the patients. The reasons for failure were mainly inability to cross the small septal collaterals and inability to deliver the balloon or dissection in the CC.[16] **Saito** reported the results of retrograde attempts in 45 patients, which were performed by a single experienced operator. He has reported the success rate of 69% in this group of patients. The retrograde CC was crossed with the wire in 82% of the patients and the septal collaterals (93%) were used in a majority of the cases. He has reported the minor perforation in 13% of the patients with no long-term squeals. **Also** reported the results of European experience with the retrograde approach for the recanalization of the coronary artery CTOs. They have reported overall success rates of 83.4% and the guide wire crossed the CC successfully in 80.6% of the cases.[17] The collateral perforation rates were reported at 6.9%. We have recently reported similar results from a consecutive series of patients performed by experienced operators and the final success rate was 89%.[18] Although the present study showed that subintimal guide wire passage was associated with the retrograde technique (10 of 25 patients, 40%), the retrograde guide wire did not necessarily enter the subintimal space at the distal cap but more often at the site of hard plaque and/or calcification in longer CTO segments (6 of 10 patients, 60%). The presence and tortuosity of collaterals are key issues in selecting a retrograde interventional strategy when treating CTOs. Non tortuous septal collaterals are preferentially used for the retrograde approach, whereas epicardial and/or tortuous collaterals are at higher risk for procedure-related vessel trauma. As a CTO lesion grows older, collateral vessels develop and become less tortuous.

In the present study, visible, continuous collaterals were more common in the Retrograde group than in the Antegrade group. **In the current study** most intramural/extramural hematomas and/or perforations were not detected angiographically, partly because angiographic dissections precluded accurate evaluation of other complication morphologies. Some of these injuries (e.g., extramural coronary hematoma or perforation) can evolve to angiographic free perforation either directly from guide wire manipulation or from subsequent ballooning or stenting.[19] Furthermore, **Erlich** et al. have reported a case of acute stent thrombosis after multiple subintimal stenting.[20] Thus, when these arterial wall injuries or subintimal stenting are detected by IVUS during the procedure, careful short- and long-term clinical follow-up and strict dual antiplatelet therapy should be recommended. Strong correlations exist between post-procedural IVUS MSA and restenosis[21],[22] Although these studies have been performed in non occlusive lesions, we believe that optimal stent expansion also will improve long-term outcomes in CTO lesions. This is the first reported series in which the retrograde angioplasty to the CTO arteries was compared to the traditional antegrade angioplasty to the CTO arteries. The success rate in this series was (93 %) in the retrograde approach and (67%)antegrade the fo approach with no serious complication. Inability of the guide wire crossing is the main reason of the procedural failure in CTO recanalization. Several attempts have been made recently to improve the recanalization rates by novel techniques. Retrograde use of the CC and approaching the CTO segment in the retrograde fashion has resulted in some success in a selected group of patients. The common reason for failed procedure during retrograde approach in both these studies was inability to cross the collaterals because of severe tortuosity and failure to deliver the balloon through the CC. The success rates of CTO recanalization has increased from 90% to 95% with the use of retrograde methods and further increased to 97% with the application of IVUS guided reverse CART in the hands of experienced operators with accumulated experience, the operator primarily applies retrograde techniques in 50% to 60% of all CTO cases, mainly difficult or failed antegrade attempts. Recently, reverse CART with IVUS guidance was applied in 60% of the retrograde cases and conventional CART in 5% of cases with retrograde wire crossing in remaining 35% of cases. Various advanced

CTO recanalization techniques including retrograde techniques (CART and reverse CART) could be considered by operators experienced in management of CTO by antegrade approaches. However, there is a learning curve and experience is needed to achieve competence levels. Retrograde approach offers an alternative approach in the patients with failed antegrade procedure or patients with suitable coronary anatomy. Since its inception a few years back, continuous improvements are seen both in the technology and in the emergence of new devices.

With the introduction of the channel dilator, the more tortuous and epicardial channels could be approached without the need for channel dilation with balloon. The channel dilator also provides good backup and easy maneuverability of the retrograde guide wire. This has further increased the utility of the retrograde channel and the success in delivering the guide wire to the CTO segment. Moreover with the reverse CART procedure as described there is minimal need to pass the balloon catheter distal to the CTO site via the CC as subintimal space can be created by the antegrade approach. IVUS guidance has proved to be beneficial in deciding on the size of the antegrade balloon to create optimal subintimal dissection and also direct visualization of the subintimal space and wire crossing.

In our series, the polymer-coated wires have crossed the CC successfully in all the cases. However, in two-thirds of the patients, the stiff guide wires were needed to negotiate through the CTO segment and they were exchanged for the soft wires at the earliest opportunity. The channel dilator was successfully used in 27 cases and was not needed in 2 patients as the wire crossing through the epicardial CC was easy. In the remaining 1 case it was difficult to pass the channel dilator because of severe bending inside the CC and the small (1.3 mm) balloon was used to provide backup support. Reverse CART was applied to a majority of the patients, except 2 patients in whom the antegrade balloon could not be delivered to the CTO segment because of severe tortuosity.

In some cases following the crossing of the CTO segment, it was difficult to negotiate the guide wire into the guide catheter. A snare wire was used in these cases to assist the procedure. With the use of septal collaterals, the collateral perforation could be seen in 5% to 10% of patients. The majorities of septal channel perforations are benign and require abandoning that channel and trying other channel. The channel dilator is safer than a balloon and rarely causes CC dissection or perforation, especially in channels with excessive beds and tortuosity. The majority of channel injury patients do not need any further treatment. In some cases, coil embolization may be required. The septal dissections or perforation seen with large series of patients with retrograde recanalization of CTO has shown low complication rates in experienced hands[18] The other potential complication is obstruction of inflow into the CC following the introduction of the channel dilator. This can rarely result in reduced visualization of the distal occluded vessel and myocardial ischemia. Therefore, it is important to avoid the dominant and tortuous CC for the access to the distal CTO segment.

Limitations

There was probably selection bias in opting for the Ante versus the Retro approach. In such a small group it might be difficult to separate technique from lesion complexity. **First**, this case series represents a small number of highly selective cases performed by an experienced operator, therefore the results may not be applicable to less experienced operators. **Second**, being a retrospective observational study, there are inherent limitations. **Third**, lack of follow-up beyond hospital stay is an important limitation. The small sample size limited the power of the statistical analysis is in this study. Non-randomized characteristics of the present study did not allow the real success rate of recanalization to be predicted precisely: the fact that no patient was sent to surgery immediately after PCI procedural failure would create a bias in the analysis of in-hospital MACE rate differences. As a result, randomized studies with larger sample sizes are needed to answer these questions.

Finally, this study comprised a relatively modest number of patients treated by only highly experienced operator; therefore, interpretation of our findings must be cautious and might not be applicable for less-experienced operators.

Limitation of retrograde approach in current stage. This technique requires years of experience in the field of treating CTO, including sophisticated wire handling and conventional antegrade techniques. The operators should not be encouraged to adopt the retrograde techniques unless they have reached a certain level of expertise. Despite all recent modifications in the retrograde approach, there is still limited retrograde access in patients with CTO lesions. The atrial, epicardial, septal and posterolateral channels are present in 60% of all CTO lesions. Predominantly retrograde techniques are dependent on creating subintimal connection and many operators hesitate to create subintimal dissection due to the risk of vessel rupture and spiral dissection. There is also potential of causing myocardial ischemia in the event of collateral injury. Although, this is seen rarely in experienced hands.

CONCLUSIONS

PCI for CTO was determined to be unsafe in remote hospitals without CABG facilities. While patients appear to benefit from successful CTO opening even in these circumstances, careful attention should be paid to the occurrence of coronary perforation. Retrograde procedure is a promising option for complex CTO lesions; especially long RCA CTOs. Although there was a higher incidence of subintimal guide wire passage and/or procedure-related vessel injury and more complex lesion morphology in the Retro group, the final results MSA and angiographic minimum lumen diameter were similar to the "simpler" lesions treated with the Ante technique. These are promising results, demonstrating safe and effective expansion of complex techniques beyond a few isolated centers. Still, operator CTO volume and experience play a large role in outcomes and—as the authors indicate—individual operator experience is not available for this particular analysis. To address the issue of operator volume, the authors used case series as a surrogate for operator volume and did not find a difference in outcomes between small series and large ones. However, as they point out, some of the small case studies were reported by groups known to have a high CTO volume; thus this is a poor surrogate. Additionally, publication bias is particularly an issue in an analysis such as this, in that those with poor results are less likely to report their outcomes. Nevertheless, we know that CTO interventions can be performed safely with a high rate of technical success, supporting the expansion of these procedures to those centers willing to make the commitment of training and meticulous technique required for these challenging procedures. These results suggest that all CTO lesions should first be managed with an antegrade approach. When there is difficulty crossing the lesion, switching to a bilateral approach is an option for lesions with well-developed collaterals.

RECOMMENDATIONS

1-further large-scale studies will be needed to define the safety issues. The retrograde techniques for CTO recanalization require extensive experience with the usage of different wires, microcatheters, and access to various CCs. **2**-Retrograde approaches offers an alternative approach in the patients with failed antegrade procedure or patients with suitable coronary anatomy. **3**-Use The IVUS can be performed (antegrade) inthe futureonce the CTO is crossed. Use of IVUS might enhance the efficacy, safety and acute results of the Retro in CTO PCI. IVUS guidance has proved to be beneficial in deciding on the size of the antegrade balloon to create optimal sub intimal dissection and also direct visualization of the subintimal space and wire crossing. **4**- Nontortuous septal collaterals are preferentially used for the retrograde approach, whereas epicardial and/or tortuous collaterals are at higher risk for procedure-related vessel trauma when there is arterial wall injuries or subintimal stenting are detected by ographyangi during the procedure, **5**- will be used IVU careful short- and long-term clinical follow-up and strict dual anti platelet therapy should be recommended. Management of patients with a CTO remains challenging. **6**-Despite the technical improvements, results are dependent of the patient selection and the operator's skill. Over-the-Wire catheters or micro catheters should be used routinely in CTO recanalization. **7**-Awareness of how to use the new generation of CTO specific Guide wires is mandatory before starting such procedures. Being familiar with different tips and tricks in manipulating these specific guide wires may allow improved personal performances. **8**-The retrograde approach to CTO requires specific training and equipment and at this stage should not be attempted outside a selected number of pilot centers. The combination of improved technology and the use of drug-eluting stents will probably broaden the PCI indications in patients with CTO.

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