

**Aortic root and extensive coronary dissections complicating recanalization of chronic right coronary artery occlusion: refraining from stenting may have a favorable outcome!**

**Kostov J, Stankovic G.**

**A**ortic root dissection is a rare, potentially life-threatening complication of revascularization procedures. We report a case of recanalization of chronic total occlusion of the right coronary artery. A huge coronary dissection with a false lumen was created using commercially available guidewires during attempts to establish a connection with the distal true vessel lumen. In addition, an aortic root dissection from the right coronary cusp occurred. The patient was asymptomatic and a decision was made to refrain from stent deployment in order not to close communications between the false, true lumen and branches. The hospital stay was uneventful and the patient was discharged on conservative management. Control angiography at 3 months revealed patency of the right coronary artery with complete healing of the aortic wall dissection and improved clinical status of the patient.

## **Intracoronary beta-brachytherapy in chronic total occlusions: A subgroup analysis from the RENO registry.**

**Jain D, Geist V, Lorenzen HP, Hartmann F, Wegscheider K, Bonan R, Urban P, Richardt G.**

**C**onventional interventional therapy has been less rewarding in chronic total occlusion (CTO). Brachytherapy by its antiproliferative and positive remodeling effect may be more efficacious. Forty-six centers registered 1,098 consecutive patients undergoing brachytherapy with the BetaCath system. Of these, 78 patients had 82 lesions (CTO) at presentation—the study population. With 67% in-stent CTO, 8% graft CTO, 4% recurrent CTO, long lesions (27.6 +/- 20.9 mm), and 31% diabetes, the cohort had high risk for recurrence. The in-hospital event rate was 1.3%. Six-month follow-up revealed 1.3% death, 5.1% myocardial infarction, 21.8% target vessel revascularization, 77.8% improved angina, 34.5% binary restenosis, 12.7% reocclusion, and 10.3% late thrombosis. The results were comparable to all other patients in the registry, although late thrombosis rate was higher in the CTO group (10.3% vs. 5.0%;  $P = 0.047$ ). In the in-stent CTO subgroup ( $n = 52$ ; 66.7%), there was no in-hospital event, no follow-up death or myocardial infarction, restenosis in 35.1%, and reocclusion in 10.8% of patients. In comparison, death or myocardial infarction was significantly higher in de novo CTO subgroup ( $P = 0.005$ ). Compared to all other in-stent restenosis patients in the registry, the patients with in-stent CTO had similar clinical and angiographic event rate. Thus, beta-brachytherapy was safe, feasible, and effective in this broad population of high-risk patients with CTO presenting in day-to-day practice. It was particularly effective in in-stent CTO, where conventional interventional strategies are disappointing.

## **Angioplasty for chronic total coronary occlusions: safety and efficacy.**

**Mathew OP, Dugal JS, Jetley V, Malani SK, Datta SK.**

**O**BJECTIVE: To determine the short term results and safety of angioplasty in chronic coronary occlusions. METHODS: Eighty consecutive patients undergoing percutaneous transluminal coronary angioplasty (PTCA) for chronic coronary occlusions were prospectively analyzed for acute success rate and safety of the procedure. RESULTS: The mean age was 46.7 years (range 30-78 years). There were 72 males and eight females. Clinical presentation was recent myocardial infarction (MI) in four cases (5%), unstable angina in 20 (25%), chronic stable angina in 24 (30%) and past history of MI in 32 (40%) cases. Vessel distribution was left anterior descending artery (LAD) in 40 (50%), left circumflex artery (LCx) in 12 (15%) and right coronary artery (RCA) in 28 (35%) cases. Lesion length varied from 8 mm to 37 mm with a mean of 16.7 mm. Acute success rate was 70% (56/80). Twenty four cases (30%) had unsuccessful result due to failure to cross with wire (18 cases) or inability to cross with the balloon (six cases). One major complication in the form of type III coronary perforation was encountered which was successfully managed surgically. CONCLUSION: Percutaneous transluminal coronary angioplasty (PTCA) in chronic total occlusion has a reasonable success rate and very low complication rate.

**Traumatic total occlusion of left main coronary artery caused by blunt chest trauma.**

**Goktekin O, Unalir A, Gorenek B, Kudaiberdieva G, Cavusoglu Y, Melek M, Aslan R, Timuralp B.**

**M**yocardial infarction is a rare complication that can occur immediately after a blunt chest trauma. We report a 36-year-old male who experienced a fatal anterolateral myocardial infarction after a nonpenetrating chest injury sustained in a car accident. Injuries of the coronary arteries associated with blunt chest trauma predominantly affect the left anterior descending artery. This is the first case of traumatic complete occlusion of the left main coronary artery (LMCA) demonstrated by coronary angiography.

## **Immediate and long-term outcome of recanalization of chronic total coronary occlusions.**

**Piscione F, Galasso G, Maione AG, Pisani A, Golino P, Leosco D, Indolfi C, Chiariello M.**

**E**ighty-three consecutive patients with 85 coronary total occlusions undergoing coronary angioplasty were retrospectively studied. Patients were divided into two groups according to the occlusion age that was < 30 days (subacute total occlusion [STO]: 25 patients; range 1-30 days) or > 30 days (chronic total occlusion [CTO]: 58 patients; range 3-144 months). All procedures were carried out using a hydrophilic guidewire. Clinical success, consisting of crossing the lesion, balloon dilatation, stent deployment without complications, was 96% in STO and 81% in CTO. Multiple stepwise logistic regression analysis identified a family history of coronary artery disease (CAD), left anterior descending and right coronary artery occlusions as independent predictors of a successful procedure. No major events occurred during or immediately after the angioplasty. After a mean follow-up of 24 +/- 2 months, no difference was found in survival or freedom from myocardial infarction or target vessel revascularization among the STO and CTO patients. Successful recanalization by using a hydrophilic guidewire was achieved in a high percentage of chronic total occlusions with a low incidence of complications and a satisfactory late clinical outcome. Family history of CAD and occlusion of left anterior descending or right coronary arteries are independent predictors of procedural success.

## **Histopathologic time course of myocardial infarct in rabbit hearts.**

**Morales C, Gonzalez GE, Rodriguez M, Bertolasi CA, Gelpi RJ.**

**I**NTRODUCTION: The histopathologic evolution of myocardial infarct and of remote zones in rabbit hearts was studied. METHODS: The left coronary artery of 55 rabbits was ligated and rabbits were sacrificed at 2, 4, 6, 8, 12, 14, 16, 18, 26, 35 and 56 days post-ligature (n=5 per group). Two rabbits were used as control and four were sham-operated. The hearts were excised, cut in slices and stained with hematoxylin-eosin, Masson's trichrome and picosirius red. The histological evaluation was semiquantitative (scale: 0 to ++). RESULTS: At day 2, the presence of neutrophils was ++, decreasing suddenly at day 4 and disappearing completely at day 6. The proliferation of cells with features of fibroblasts increased from days 4 to 14 post-occlusion. Coagulation necrosis in mid-myocardium during the first week was ++. Subendocardial myocytolysis was evident from day 2 up to day 56 post-infarction. During the second week, proliferation of lymphocytes and macrophages (++), granulation tissue formation (++) and incipient traces of fibrosis that peaked at day 35 were observed. Scarring was complete at day 56 (++) . In remote zones (right ventricle and septum), the proliferation of cells+ on Vimentin was observed at day 2, and perivascular, interstitial and endocardial fibrosis started to increase at day 6 and peaked at day 16. CONCLUSION: Although myocardial infarction in rabbits maintains the essence of the infarct chronology, some differences as the early presence of cells+ on Vimentin and subendocardial fibrosis in infarcted areas, and also the rapid increase and early disappearance of neutrophils appear when other species are considered. An interesting finding was the early proliferation of cells with features of fibroblasts in remote zones.

## **Fate of collateral circulation after successful coronary angioplasty of total occlusion assessed by coronary angiography and myocardial contrast echocardiography.**

**Ha JW, Cho SY, Chung N, Choi DH, Choi BJ, Jang Y, Shim WH, Kim SS.**

**A** well-developed collateral circulation is frequently observed in patients with total coronary occlusion. However, the fate of the collateral circulation after successful percutaneous transluminal coronary angioplasty (PTCA) has not been fully characterized. The purpose of this study was to compare the efficacy of coronary angiography and myocardial contrast echocardiography (MCE) in the evaluation of the collateral circulation after PTCA and to assess the temporal changes of the collateral circulation after successful PTCA of a totally occluded artery by using these 2 diagnostic methods. The study group was comprised of 20 consecutive patients (16 male, mean age 54 years) who underwent elective PTCA for total coronary occlusion. Coronary angiography was performed before, immediately after, and 24 hours after PTCA. MCE was also performed before, immediately after, and 24 hours after PTCA, by the intracoronary injection of sonicated radiographic contrast medium. According to the angiographic findings, the collateral circulation was graded on a scale of 0 to 3 as follows: 0 = no visible filling; 1 = collateral filling of side branches; 2 = partial collateral filling of the epicardial artery; 3 = complete filling of the epicardial artery. By MCE, myocardial perfusion by the collateral circulation was assessed by scoring the contrast pattern of collateral-dependent myocardial segments as follows: 0 = none; 0.5 = patchy or epicardial; 1 = homogeneous. The left anterior descending artery was occluded in 12 patients and the right coronary artery in 8 patients. Coronary angiographic collateral grades before PTCA were grade 2 in 5 patients and grade 3 in 15. PTCA with stenting was successfully performed in all patients without significant residual stenosis. Coronary angiography showed collateral circulation disappeared after PTCA in all patients. However, residual collateral perfusion was observed in 7 patients by MCE, performed immediately after PTCA (score 1 in 3 patients; score 0.5 in 4 patients). This residual collateral perfusion could be demonstrated even 24 hours after PTCA by MCE in 3 patients (all patients were 0.5 in myocardial perfusion score). In conclusion, successful PTCA with stenting of a totally occluded coronary artery leads to a disappearance of collateral vessels by coronary angiography in most of the patients. However, although angiographically not visible, coronary collateral circulation may persist even 24 hours after successful PTCA of a totally occluded artery demonstrated by MCE.

## **Angioplasty for chronic total coronary occlusions: safety and efficacy.**

**Mathew OP, Dugal JS, Jetley V, Malani SK, Datta SK.**

**O**BJECTIVE: To determine the short term results and safety of angioplasty in chronic coronary occlusions. **METHODS:** Eighty consecutive patients undergoing percutaneous transluminal coronary angioplasty (PTCA) for chronic coronary occlusions were prospectively analyzed for acute success rate and safety of the procedure. **RESULTS:** The mean age was 46.7 years (range 30-78 years). There were 72 males and eight females. Clinical presentation was recent myocardial infarction (MI) in four cases (5%), unstable angina in 20 (25%), chronic stable angina in 24 (30%) and past history of MI in 32 (40%) cases. Vessel distribution was left anterior descending artery (LAD) in 40 (50%), left circumflex artery (LCx) in 12 (15%) and right coronary artery (RCA) in 28 (35%) cases. Lesion length varied from 8 mm to 37 mm with a mean of 16.7 mm. Acute success rate was 70% (56/80). Twenty four cases (30%) had unsuccessful result due to failure to cross with wire (18 cases) or inability to cross with the balloon (six cases). One major complication in the form of type III coronary perforation was encountered which was successfully managed surgically. **CONCLUSION:** Percutaneous transluminal coronary angioplasty (PTCA) in chronic total occlusion has a reasonable success rate and very low complication rate.

## TOTAL OCCLUSION

1. Aortic root and extensive coronary dissections complicating recanalization of chronic right coronary artery occlusion: refraining from stenting may have a favorable outcome!

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J Invasive Cardiol 2003 Mar;15(3):164-6

2. Intracoronary beta-brachytherapy in chronic total occlusions: A subgroup analysis from the RENO registry.

Jain D, Geist V, Lorenzen HP, Hartmann F, Wegscheider K, Bonan R, Urban P, Richardt G.

Catheter Cardiovasc Interv 2003 Mar;58(3):322-9

3. Angioplasty for chronic total coronary occlusions: safety and efficacy.

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J Assoc Physicians India 2002 Oct;50:1251-4

4. Traumatic total occlusion of left main coronary artery caused by blunt chest trauma.

Goktekin O, Unalir A, Gorenek B, Kudaiberdieva G, Cavusoglu Y, Melek M, Aslan R, Timuralp B.

J Invasive Cardiol 2002 Aug;14(8):463-5

5. Immediate and long-term outcome of recanalization of chronic total coronary occlusions.

Piscione F, Galasso G, Maione AG, Pisani A, Golino P, Leosco D, Indolfi C, Chiariello M.

J Interv Cardiol 2002 Jun;15(3):173-9

6. Histopathologic time course of myocardial infarct in rabbit hearts.

Morales C, Gonzalez GE, Rodriguez M, Bertolasi CA, Gelpi RJ.

Cardiovasc Pathol 2002 Nov-Dec;11(6):339-45

7. Fate of collateral circulation after successful coronary angioplasty of total occlusion assessed by coronary angiography and myocardial contrast echocardiography.

Ha JW, Cho SY, Chung N, Choi DH, Choi BJ, Jang Y, Shim WH, Kim SS.

J Am Soc Echocardiogr 2002 May;15(5):389-95

8. Angioplasty for chronic total coronary occlusions: safety and efficacy.

Mathew OP, Dugal JS, Jetley V, Malani SK, Datta SK.

J Assoc Physicians India 2002 Oct;50:1251-4

Am Heart J 2001 Aug;142(2):301-8

Predictors of improvement in left ventricular function after percutaneous revascularization of occluded

coronary arteries: a report from the Total Occlusion Study of Canada (TOSCA).

Dzavik V, Carere RG, Mancini GB, Cohen EA, Catellier D, Anderson TE, Barbeau G, Lazzam C, Title LM, Berger PB, Labinaz M, Teo KK, Buller CE; The Total Occlusion Study of Canada Investigators.

**BACKGROUND:** The Total Occlusion Study of Canada (TOSCA) is a multicenter, randomized trial evaluating the effect of stenting with  $\geq 1$  heparin-coated stent on long-term patency after percutaneous coronary intervention by balloon angioplasty of occluded coronary arteries. The purpose of the current study was to compare the effect of stenting and balloon angioplasty on global left ventricular ejection fraction (LVEF) and regional wall motion and to examine what clinical and angiographic factors may have an effect on left ventricular function in this setting. **METHODS AND RESULTS:** Analysis at the core angiographic laboratory of paired baseline and follow-up left ventricular angiograms, as well as target vessel patency, was possible in 244 of 410 cases. An improvement in LVEF was observed in the entire group (59.4%  $\pm$  11% to 61.0%  $\pm$  11%,  $P = .003$ ). The LVEF change was +1.84  $\pm$  7.54 in the stent group ( $P = .009$ ) and 1.28  $\pm$  8.16 in the percutaneous transluminal coronary angioplasty group ( $P = .085$ ). There was no significant intergroup difference. Patients with duration of occlusion  $\leq 6$  weeks had an improvement in LVEF (+2.98  $\pm$  8.68,  $P = .0006$ ), whereas those with an occlusion duration of  $> 6$  weeks had no improvement (+0.48  $\pm$  7.01,  $P$  not significant). Multivariate analysis revealed baseline LVEF  $< 60\%$ , duration of occlusion  $\leq 6$  weeks, and Canadian Cardiology Society angina class I or II to be independent predictors of improvement in LVEF. **CONCLUSIONS:** The restoration of coronary patency of nonacute occluded coronary arteries is associated with a small but significant improvement in regional and global left ventricular function, especially in patients with recent occlusions and depressed left ventricular function. In spite of significant effect on long-term patency, stenting of nonacute coronary occlusions does not result in significantly better left ventricular function compared with balloon angioplasty in this setting.

J Am Coll Cardiol 2001 Aug;38(2):409-14

Procedural outcomes and long-term survival among patients undergoing percutaneous coronary intervention of a chronic total occlusion in native coronary arteries: a 20-year experience.

Suero JA, Marso SP, Jones PG, Laster SB, Huber KC, Giorgi LV, Johnson WL, Rutherford BD.

**OBJECTIVES:** The study compared procedural outcomes and long-term survival for patients undergoing percutaneous coronary intervention (PCI) of a chronic total coronary artery occlusion (CTO) with a matched non-CTO cohort to determine whether successful PCI of a CTO is associated with improved survival. **BACKGROUND:** Percutaneous coronary intervention of a CTO is a common occurrence, and the long-term survival for patients with successful PCI of a CTO has not been clearly defined. **METHODS:** Between June 1980 and December 1999, a total of 2,007 consecutive patients underwent PCI for a CTO. Utilizing propensity scoring methods, a matched non-CTO cohort of 2,007 patients was identified and compared to the CTO group. The cohorts were stratified into successful and failed procedures. **RESULTS:** The in-hospital major adverse cardiac event (MACE) rate was 3.8% in the CTO cohort. Technical success has improved over the last 10 years (overall 74.4%, slope 1.0%/yr,  $p = 0.02$ ,  $R^2 = 49.9\%$ ) as did procedural success (overall 69.9%, slope 1.2%/yr,  $p = 0.02$ ,  $R^2 = 51.5\%$ ) without a concomitant increase in in-hospital MACE rates (slope 0.1%/yr,  $p = 0.7$ ). There was a distinct 10-year survival advantage for successful CTO treatment compared with failed CTO treatment (73.5% vs. 65.1%,  $p = 0.001$ ). The CTO versus non-CTO 10-year survival was the same (71.2% vs. 71.4%,  $p = 0.9$ ). Diabetics in the CTO cohort had a lower 10-year survival compared with nondiabetics (58.3% vs. 74.3%,  $p < 0.0001$ ). **CONCLUSIONS:** These data represent follow-up of the largest reported series of patients undergoing PCI for a CTO. The 10-year survival rates for matched non-CTO and the CTO cohorts were similar. Success rates have continued to improve without an accompanying increase in MACE rates. A successfully revascularized CTO confers a significant 10-year survival advantage compared with failed revascularization.

Circulation 2001 Sep 4;104(10):1129-34

Microvascular dysfunction in chronic total coronary occlusions.

Werner GS, Ferrari M, Richartz BM, Gastmann O, Figulla HR.

**BACKGROUND:** Microvascular dysfunction is defined as reduced coronary flow reserve in the absence of an epicardial stenosis. This study determined its prevalence and relation to regional myocardial function in chronic total coronary occlusions (TCO). **METHODS AND RESULTS:** After recanalization and stenting of a TCO (duration, >4 weeks) in 42 patients, coronary flow velocity reserve (CFVR) was measured by intracoronary Doppler. In a subset of 27 patients, intracoronary pressure was recorded to obtain the fractional flow reserve

(FFR). In 21 patients, the CFVR was reassessed after 24 hours. CFVR was  $<2.0$  in 55% of all patients. In the subgroup with simultaneous pressure recordings, 52% of patients showed a CFVR $<2.0$  and a FFR $\geq 0.75$ , indicating microvascular dysfunction. Both reduced CFVR and reduced FFR occurred in only 2 patients (7.7%). CFVR and FFR were not correlated ( $r=0.03$ ). A low CFVR was associated with a higher baseline average peak velocity ( $35.6\pm 16.6$  versus  $22.4\pm 11.5$  cm/s;  $P=0.006$ ). Doppler parameters did not change within 24 hours. Regional dysfunction had no influence on CFVR. Patients with diabetes and/or hypertension had a lower CFVR than those without this comorbidity ( $1.86\pm 0.69$  versus  $2.36\pm 0.45$ ;  $P<0.05$ ). CONCLUSIONS: Microvascular dysfunction was observed in 55% of TCOs, independent of the impairment of regional myocardial function. Dysfunction was observed more often in patients with diabetes and hypertension. Neither CFVR or FFR alone is appropriate for assessing angioplasty results in patients with a TCO; CFVR should be combined with FFR to differentiate microvascular dysfunction from residual coronary stenosis or diffuse disease.

Heart 2001 Oct;86(4):438-43

Influence on collateral flow of recanalising chronic total coronary occlusions: a case-control study.

Pohl T, Hochstrasser P, Billinger M, Fleisch M, Meier B, Seiler C.

**OBJECTIVE:** To assess the effect of recanalisation on collateral flow in a case-control study in patients with and without chronic total coronary occlusions. **DESIGN:** In 54 patients undergoing percutaneous transluminal coronary angioplasty (PTCA) (mean (SD) age 61 (6) years), coronary collateral flow was measured by intracoronary pressure or Doppler guide wires at the end of repeated balloon occlusions. Coronary collateral flow index (collateral flow relative to normal antegrade flow) during the first two balloon inflations in 27 patients with a chronic total occlusion (occlusion group) was compared with that of 27 patients matched for age, sex, and collateral flow index at the first occlusion and with a coronary artery diameter stenosis  $\leq 80\%$  (stenosis group). **RESULTS:** Following revascularisation, collateral flow index decreased in 17 of the patients in the occlusion group (63%) and in eight of the patients in the stenosis group (30%) ( $p = 0.03$  between groups). The overall change of collateral flow index between the first and the second balloon occlusion was  $-0.04$  (0.01) in the occlusion group ( $p = 0.07$  for paired comparison; from  $0.29$  (0.17) to  $0.25$  (0.14)), and  $+0.02$  (0.06) in the stenosis group ( $p = 0.06$  for paired comparison; from  $0.27$  (0.13) to  $0.30$  (0.15)). The trend to collateral enhancement in the stenosis group differed significantly from the occlusion group ( $p = 0.01$ ). **CONCLUSIONS:** While repeated coronary balloon occlusions induce collateral recruitment in the majority of patients with

moderate stenoses, recanalisation of chronic total coronary occlusions is more often associated with collateral flow reduction. A later decrease in collateral flow by involution of collateral channels cannot be excluded by this study but has not been reported so far.

J Am Coll Cardiol 2001 Nov 1;38(5):1328-32

Noninvasive detection of total occlusion of the left anterior descending coronary artery with transthoracic Doppler echocardiography.

Watanabe N, Akasaka T, Yamaura Y, Akiyama M, Koyama Y, Kamiyama N, Neishi Y, Kaji S, Saito Y, Yoshida K.

**OBJECTIVES:** The purpose of this study was to evaluate the value of transthoracic Doppler echocardiography (TTDE) for the noninvasive detection of total left anterior descending coronary artery (LAD) occlusion. **BACKGROUND:** Total coronary occlusion is associated with an adverse long-term prognosis, and mechanical revascularization may be required for the patient with total coronary occlusion. However, a noninvasive diagnosis of total coronary occlusion before coronary angiography (CAG) has been difficult, especially in patients without clinical signs. **METHODS:** We studied 103 consecutive patients who underwent CAG for the evaluation of coronary artery disease. The study group consisted of 16 patients with total LAD occlusion (group A) and 87 patients without total LAD occlusion (group B). Coronary flow velocity in the mid-portion of the LAD was recorded by TTDE. **RESULTS:** Adequate spectral Doppler recordings of diastolic flow in the LAD were obtained in 98 study patients (95%; 15 patients in group A and 83 patients in group B). In group A, retrograde LAD flow was obtained in 14 (93%) of 15 patients. The mean diastolic velocity of the retrograde flow was 21.0 +/- 6.1 cm/s. In group B, antegrade LAD flow was obtained in all 83 patients (100%). The mean diastolic velocity of the antegrade flow was 21.5 +/- 7.1 cm/s. Retrograde LAD flow by TTDE had a sensitivity of 93% and a specificity of 100% for the detection of total LAD occlusion. **CONCLUSIONS:** Retrograde flow in the LAD by TTDE is a highly sensitive and specific finding that can be used to noninvasively diagnose total LAD occlusion.

Am Heart J 2001 Nov;142(5):776-81

Does ticlopidine reduce reocclusion and other adverse events after successful balloon angioplasty of occluded coronary arteries? Results from the Total Occlusion Study of Canada (TOSCA).

Berger PB, Dzavik V, Penn IM, Catellier D, Buller CE.

**OBJECTIVES:** Ticlopidine reduces stent thrombosis and other adverse events among patients receiving coronary stents. Whether ticlopidine is beneficial after balloon angioplasty is unknown. Our purpose was to compare the clinical outcome of patients undergoing balloon angioplasty treated with both aspirin and ticlopidine versus aspirin alone. **METHODS AND RESULTS:** We performed a databank analysis of the Total Occlusion Study of Canada (TOSCA), a randomized trial with angiographic follow-up comparing the frequency of reocclusion after angioplasty of a subtotal or total coronary occlusion in patients receiving  $\geq 1$  heparin-coated Palmaz-Schatz stent versus balloon angioplasty alone. In TOSCA, 102 patients undergoing balloon angioplasty were treated with both aspirin and ticlopidine (generally for 15-30 days) and 94 were treated with aspirin alone, by physician preference. After 6 months, failure to sustain patency (less than Thrombolysis in Myocardial Infarction [TIMI] grade 3 flow on follow-up angiography) occurred in 23% of patients on ticlopidine and aspirin versus 16% of patients on aspirin alone ( $P = .21$ ); the frequency of target vessel revascularization was also similar in the 2 groups (32% vs 25%,  $P = .27$ ). Myocardial infarction was infrequent in both groups (2.0% vs 1.1%, respectively,  $P$  not significant). Patients treated with aspirin and ticlopidine had more adverse angiographic and procedural characteristics, including longer lesions and treatment lengths. Multivariate analysis to adjust for these and other differences failed to reveal a benefit of ticlopidine in maintaining patency and reducing adverse clinical events. **CONCLUSIONS:** After balloon angioplasty of a subtotal or total coronary occlusion, no reduction in adverse events was observed among patients in whom ticlopidine was added to aspirin, even after adjustment for clinical and lesion characteristics.

Circulation 2001 Dec 4;104(23):2784-90

Collateral function in chronic total coronary occlusions is related to regional myocardial function and duration of occlusion.

Werner GS, Ferrari M, Betge S, Gastmann O, Richartz BM, Figulla HR.

**BACKGROUND:** Collateral circulation can maintain myocardial function and viability in chronic total coronary occlusion (TCO). The present study evaluates the relation of myocardial function and duration of occlusion to collateral function. **METHODS AND RESULTS:** A total of 50 patients underwent a successful recanalization of a TCO (>4 weeks?duration). Collateral function was assessed by intracoronary Doppler and pressure recordings before the first balloon inflation and after PTCA had been completed. Collateral function was assessed by Doppler- (CFI(D)) and pressure-derived collateral flow indices (CFI(P)), as well as indices of collateral (R(Coll)) and peripheral resistance (R(P)). Patients with normokinesia had lower R(Coll) (4.9+/-2.5 versus 11.8+/-8.2 mm Hg. cm(-1). s(-1); P=0.033) and lower R(P) (3.8+/-1.9 versus 6.1+/-4.1 mm Hg. cm(-1). s(-1); P=0.031) than those with akinesia. Patients with akinesia and a TCO duration of <=3 months had the highest R(Coll) and R(P), whereas those with akinesia and a longer TCO duration had similar collateral function as patients with normokinesia. After PTCA, CFI(D) and CFI(P) decreased from 0.37+/-0.20 to 0.21+/-0.17 (P<0.001) and from 0.44+/-0.12 to 0.36+/-0.11 (P<0.001), respectively, with an increase in R(Coll) of 139+/-128% (P<0.001) and R(P) by 65+/-99% (P=0.003). This attenuation of collateral function was less pronounced with epicardial collaterals than with intramyocardial collaterals. **CONCLUSIONS:** Collateral function was better in patients with TCO and normal regional function than in those with impaired regional function. In the latter group, collateral function improvement was time dependent. After recanalization, the recruitable collateral function was attenuated because of an increase of R(Coll) and R(P).

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versus 11.8 $\pm$ 8.2 mm Hg. cm(-1). s(-1); P=0.033) and lower R(P) (3.8 $\pm$ 1.9 versus 6.1 $\pm$ 4.1 mm Hg. cm(-1). s(-1); P=0.031) than those with akinesia. Patients with akinesia and a TCO duration of  $\leq$ 3 months had the highest R(Coll) and R(P), whereas those with akinesia and a longer TCO duration had similar collateral function as patients with normokinesia. After PTCA, CFI(D) and CFI(P) decreased from 0.37 $\pm$ 0.20 to 0.21 $\pm$ 0.17 (P<0.001) and from 0.44 $\pm$ 0.12 to 0.36 $\pm$ 0.11 (P<0.001), respectively, with an increase in R(Coll) of 139 $\pm$ 128% (P<0.001) and R(P) by 65 $\pm$ 99% (P=0.003). This attenuation of collateral function was less pronounced with epicardial collaterals than with intramyocardial collaterals. CONCLUSIONS: Collateral function was better in patients with TCO and normal regional function than in those with impaired regional function. In the latter group, collateral function improvement was time dependent. After recanalization, the recruitable collateral function was attenuated because of an increase of R(Coll) and R(P).

J Am Coll Cardiol 1996;28:1444-51

#### Stenting in Chronic Coronary Occlusion (SICCO): A Randomized, Controlled Trial of Adding Stent Implantation After Successful Angioplasty

Per Anton Sirnes, MD, Svein Golf, MD, PhD, Yngvar Myreng, MD, PhD, Per Molstad, MD, PhD, Hakan Emanuelsson, MD, PhD, Per Albertsson, MD, PhD, Magne Brekke, MD, Arild Mangschau, MD, PhD, Knut Endresen, MD, PhD, John Kjekshus, PhD

**Objectives.** This study investigated whether stenting improves long-term results after recanalization of chronic coronary occlusions.

**Background.** Restenosis is common after percutaneous transluminal coronary angioplasty (PTCA) of chronic coronary occlusions. Stenting has been suggested as a mean of improving results, but its use has not previously been investigated in a randomized trial.

**Methods.** We randomly assigned 119 patients with a satisfactory result after successful recanalization by PTCA of a chronic coronary occlusion to 1) a control (PTCA) group with no other intervention of Palmaz-Schatz stents with full anticoagulation. Coronary angiography was performed before randomization, after stenting and at 6-month follow-up.

**Results:** Inguinal bleeding was more frequent in the stent group. There were no deaths. One patient had a myocardial infarction. Subacute occlusion within 2 weeks occurred in four patients in the stent group and in the PTCA group. At follow-up, 57% of patients with stenting were free from angina compared with 24% of

patients with PTCA only ( $p < 0.001$ ). Angiographic follow-up data were available in 114 patients. Restenosis (50% diameter stenosis) developed in 32% of patients with stenting and in 74% of patients with PTCA only ( $p < 0.001$ ); reocclusion occurred in 12% and 26%, respectively ( $p = 0.058$ ). Minimal lumen diameter (mean  $\pm$  SD) at follow-up was  $1.92 \pm 0.95$  mm and  $1.11 \pm 0.78$  mm, respectively ( $p < 0.001$ ). Target lesion revascularization within 300 days was less frequent in patients with PTCA only (22% vs. 42%,  $p = 0.025$ ).

**Conclusions.** Stent implantation improved long-term angiographic and clinical results after PTCA of chronic coronary occlusions and is thus recommended regardless of primary PTCA result.

## Summary

J Am Coll Cardiol 1997;29:955-63

### Histologic Correlates of Angiographic Chronic Total Coronary Artery Occlusions : Influence of Occlusion Duration on Neovascular Channel Patterns and Intimal Plaque Composition

S. Sanjay Srivatsa, MBBChir, MRCP, William D. Edwards, MD, FACC, Christine M. Boos, BSA, Diane E. Grill, MS, Giuseppe M. Sangiorgi, MD, Kirk N. Garratt, MD, FACC, Robert S. Schwartz, MD, FACC and David R. Holmes Jr, MD, FACC.

**Objectives.** Age-related changes in histologic composition and neovascular channel (NC) pattern of angiographic chronic total coronary artery occlusions (CTOs) were studied to define histologic correlates of age-related revascularization profiles and neovascular channel formation.

**Background.** Revascularization of CTOs is frequently characterized by inability to cross or dilate the lesion and a high incidence of reocclusion or restenosis but low periprocedural ischemic complication rates. Little is known about the histopathologic basis of these observations.

**Methods.** Ninety-six angiographic CTOs from autopsy studies in 61 patients who had undergone coronary angiography within 3 months of death were studied. Abrupt plaque rupture was excluded. Occlusion segments were analyzed for 1) histologic composition as a function of lesion age; and 2) NC pattern as a function of lesion age and intimal plaque (IP) composition.

**Results.** Cholesterol and foam cell-laden IP was more frequent in younger lesions ( $p = 0.0007$ ), whereas fibrocalcific IP increased with CTO age ( $p = 0.008$ ). IP NCs arose directly from adventitial vasa vasorum and were anatomically and quantitatively related in terms of number and size ( $p = 0.0001$ ) to the extent of IP cellular

inflammation. IP cellular inflammation exceeded that found in the adventitia ( $p < 0.001$ ) or media ( $p = 0.0001$ ) across all CTO ages. In CTOs  $<1$  year old, the adventitia was associated with a larger number and size of NCs relative to the IP ( $p = 0.0006$  and  $p = 0.009$ ), media ( $p = 0.0001$  and  $p = 0.002$ ) and recanalized lumen ( $p = 0.0001$  and  $p = 0.001$ ). In CTOs  $>1$  year old, the adventitia and IP NC numbers were similar and exceeded NC numbers found in the media ( $p = 0.0001$ ) and recanalized lumen ( $p = 0.0001$  and  $p = 0.003$ ).

Conclusions. Angiographic CTO frequently corresponds to less than complete occlusion by histologic criteria. Age-related changes in IP composition from cholesterol laden to fibrocalcific may explain the adverse revascularization profile of older CTOs. IP NC growth derived from the adventitia increases with age and is strongly associated with IP cellular inflammation. IP NC formation may protect against the flow-limiting effects of IP growth.

Figure. Frequency distribution plots. A, NC number score according to vessel wall location in CTOs  $<1$  year old. The adventitia (AV) is associated with a greater number of NCs relative to the intimal plaque (IP) ( $p = 0.0006$ ), media (Med) ( $p = 0.0001$ ) and recanalized lumen (Lum) ( $p = 0.0001$ ). B, NC number score according to vessel wall location in CTOs  $>1$  year old. The number of NCs in the adventitia is similar to that in the IP but exceeds that found in either the media ( $p = 0.0001$ ) or recanalized lumen ( $p = 0.0001$ ). C, Cellular inflammation score according to vessel wall location in CTOs  $<1$  year old. The IP is associated with a greater intensity of cellular inflammation relative to that in either the adventitia ( $p = 0.009$ ) or the media ( $p = 0.0001$ ). D, Cellular inflammation scores according to vessel wall location in CTOs  $>1$  year old. The IP has a greater intensity of inflammation than that of the adventitia ( $p = 0.0001$ ), which is similar to that of the media.

The American Journal of Cardiology, 80:11:1419-1423

Recanalization of Total Coronary Occlusions Using a Laser Guidewire (The European TOTAL Surveillance Study)

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The success rates of coronary angioplasty for the treatment of chronic total occlusions are less favorable than for coronary stenosis. Therefore, a new laser guidewire (LW) was designed to facilitate the crossing of chronic

total occlusions. We report on the results of a European multicenter surveillance study, evaluating the laser guidewire performance. Between May 1994 and July 1996, 345 patients (age  $59 \pm 10$  years, 291 men) with chronic total occlusions were enrolled in 28 European centers. The median age of occlusion was 29 weeks (range 2 to 884), the occlusion length  $19 \pm 10$  mm. LW recanalization was successful in 205 patients (59%). LW perforation occurred in 73 patients (21%), with hemodynamic consequences in 4 (1%). There were no deaths, emergency coronary artery bypass graft surgery, or Q-wave myocardial infarctions. In a multivariate regression analysis an occlusion age of  $<40$  weeks ( $p = 0.001$ , RR = 1.34) and an occlusion length  $<30$  mm ( $p = 0.01$ , RR = 1.59) were independent predictors of success. Results indicate that the LW is an effective and safe tool in the treatment of chronic total occlusion refractory to conventional guidewires.

Journal of the American College of Cardiology, 31:2:275-280

#### Stenting of Nonacute Total Coronary Occlusions: Predictors of Late Angiographic Outcome

Thomas Rau, MD, Joachim Schofer, MD, Michael Schluter, PhD, Andreas Seidensticker, MD, Jurgen Berger, PhD, Detlef G. Mathey, MD, FACC

**Objectives.** This study was designed to determine and assess factors predictive of the intermediate-term outcome of stenting of nonacute total coronary occlusions.

**Background.** Balloon angioplasty of recanalized coronary occlusions is associated with a combined restenosis/reocclusion rate of up to 65%. Adjunctive stenting holds the potential to reduce this rate significantly. However, variables affecting the late angiographic outcome of coronary stenting in the setting of a total occlusion have not been elucidated sufficiently.

**Methods.** Coronary stenting was performed in 143 consecutive patients with a nonacute total occlusion; 120 of these patients (84%), with a total of 121 occlusions, underwent repeat angiography within 6 months and comprised the study group. High pressure stent implantation aimed to cover the site of the occlusion as well as adjacent diameter stenoses  $\geq 70\%$  and all possibly induced dissections. Pertinent angiographic and procedural variables obtained at the time of the intervention were entered into a multivariate logistic regression analysis model to assess their influence on the angiographic outcome at follow-up.

**Results.** Mean preinterventional reference lumen diameter for the 121 vessels was  $2.99 \pm 0.53$  mm (mean  $\pm$  SD); occlusion length ranged from 4 to 44 mm (median of 7.7). After balloon angioplasty, dissections were found in 80% of patients. Lesions were covered with stents a median of 16 mm in length (range 8 to 53). The

minimal lumen diameter (MLD) achieved after stenting was  $2.89 \pm 0.48$  mm. After a median follow-up period of 4.5 months, mean MLD was assessed at  $1.91 \pm 0.90$  mm, corresponding to a loss index of  $0.34 \pm 0.31$ . There were 27 vessels with a nonocclusive restenosis 50% and 8 with a reocclusion, for a combined restenosis/reocclusion rate of 29%. Factors found to adversely influence angiographic outcome were a post-stenting MLD  $< 2.54$  mm, a stented vessel segment length  $>16$  mm, a balloon/vessel diameter ratio for final stent expansion  $< 1.00$  and the presence of a dissection after balloon angioplasty.

**Conclusions.** Compared with previous reports on stand-alone balloon angioplasty, stenting of nonacute total coronary occlusions lowers the 6-month restenosis/reocclusion rate to ~30%. The late procedural outcome is independently and statistically significantly influenced by the MLD after stenting, the length of the stented vessel segment, the balloon/vessel diameter ratio for final stent expansion and the incidence of dissections after balloon angioplasty.

The American Journal of Cardiology, 80:9:1150-1154

#### Effects of Stenting of Recent or Chronic Coronary Occlusions on Late Vessel Patency and Left Ventricular Function

Eric Van Belle, MD, Philippe Blouard, MD, Eugene P. McFadden, MRCP, Jean-Marc Lablanche, MD, Christophe Bauters, MD, Michel E. Bertrand, MD

Due to high rates of late vessel reocclusion, balloon angioplasty of recent or chronic coronary occlusions is not associated with a sustained improvement in left ventricular function. Recent studies have suggested that stent implantation at coronary occlusions significantly reduces late vessel occlusion. We thus designed a study to analyze the effect of stent implantation at coronary occlusions on late vessel patency and left ventricular function. Twenty-four consecutive patients with recent or chronic coronary occlusions had successful stent implantation and were enrolled in a 6-month angiographic follow-up program. Contrast left ventricular cineangiography, at baseline and 6-month follow-up, as well as preprocedural, postprocedural, and follow-up angiograms analyzed with quantitative angiography were available in 22 of the patients (92%). At follow-up, no vessel reocclusion was observed and 32% of the patients, as analyzed by the  $>50\%$  diameter stenosis criterion, had restenosis. There was a significant improvement in global left ventricular function with a decrease in both left ventricular end-diastolic volume index (LVEDVI,  $p < 0.01$ ) and left ventricular end-systolic volume index (LVESVI,  $p < 0.0001$ ) and an increase in left ventricular ejection fraction (LVEF,  $p < 0.0001$ ).

Similarly, regional wall motion in the territory of the recanalized artery was also significantly improved ( $p < 0.05$ ). These effects were associated with a reduction in left ventricular filling pressure ( $p < 0.0001$ ). Stent implantation following balloon angioplasty of recent or chronic coronary occlusion is associated with a low rate of late vessel reocclusion, a reduction in cardiac volume, and an increase in ejection fraction. Such effects on left ventricular volumes could have a significant impact on patient survival.

Journal of the American College of Cardiology, 31:2:281-288

### Wiktor Stent for Treatment of Chronic Total Coronary Artery Occlusions: Short- and Long-Term Clinical and Angiographic Results From a Large Multicenter Experience

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**Objectives.** This study reports the first multicenter experience with the Wiktor coil stent for treatment of chronic total coronary artery occlusions (CTOs).

**Background.** Percutaneous transluminal coronary angioplasty (PTCA) of CTO is associated with very high restenosis and reocclusion rates. Coronary stenting has been proposed as a means of improving outcome. However, the Wiktor device for CTOs has never been tested in a large patient sample.

**Methods.** From January 1993 to December 1996, 89 patients with 91 CTOs underwent Wiktor stent implantation after successful PTCA. The post-stenting regimen consisted of warfarin (Coumadin) plus aspirin in the initial 49 patients (55%) and aspirin plus ticlopidine in 40 patients (45%).

**Results.** Stenting was successful in 87 patients (98%). At 1 month, 6% of patients had subacute stent thrombosis, 3% had a major bleeding event, and 1% had access-site complications. Subacute stent thrombosis showed univariate association with warfarin therapy ( $p = 0.009$ ). Angiographic follow-up was obtained in 76 (93%) of 82 eligible patients. The restenosis rate was 32%, including 4% reocclusions. By multiple logistic regression analysis, restenosis was independently associated with multiple stents (adjusted odds ratio [OR] 27.67, 95% confidence interval [CI] 4.25 to 79.95,  $p = 0.0008$ ) and increasing values of occlusion length (adjusted OR 1.23, 95% CI 1.09 to 1.39,  $p = 0.001$ ). Freedom from death, myocardial infarction or stented vessel revascularization was 87% and 72% at 1 and 3 years, respectively.

**Conclusions.** Short- and long-term clinical and angiographic outcomes are favorable in patients undergoing

Wiktor stent implantation in CTO. Further technical improvement is needed to reduce the restenosis rate in patients with long lesions and multiple stents.

JACC 1999;33:395-402

A randomized trial of elective stenting after balloon recanalization of chronic total occlusions

Martin Hoher, Jochen Wohrle, Olaf C. Grebe, Matthias Kochs, Hans-H Osterhues, Vinzenz Hombach and Arnd B. Buchwald

#### OBJECTIVES

The aim of this study was to assess the role of Wiktor stent implantation after recanalization of chronic total coronary occlusions with regard to the clinical and angiographic outcome after six months.

#### BACKGROUND

Beside the common use of stents in clinical practice, the number of stent indications proven by randomized trials is still limited.

#### METHODS

Eighty-five patients with a thrombolysis in myocardial infarction grade 0 chronic coronary occlusion were examined. After standard balloon angioplasty, the patients were randomly assigned to stent implantation, or percutaneous transluminal coronary angioplasty (PTCA) alone (no further intervention). Quantitative coronary angiography was performed at baseline and after six months.

#### RESULTS

The minimal lumen diameter did not differ immediately after recanalization (stent group  $1.61 \pm 0.30$  mm vs. PTCA group  $1.65 \pm 0.36$  mm), and increased after stent implantation to  $2.51 \pm 0.41$  mm. After six months, the stent group still had a significantly greater lumen ( $1.57 \pm 0.59$  vs.  $1.06 \pm 0.90$  mm;  $p < 0.01$ ) and a significantly lower restenosis and reocclusion rate (32% and 3%) compared with the PTCA group (64% and 24%); restenosis analysis according to treatment was 72% (PTCA) versus 29% (stent,  $p < 0.01$ ). Late loss was equal in both groups. At follow-up, the stent patients had a better angina class ( $p < 0.01$ ), and fewer cardiac events ( $p < 0.03$ ). A meta-analysis including this trial and three other controlled trials with the Palmaz-Schatz stent showed concordant results.

#### CONCLUSIONS

Stent implantation after reopening of a chronic total occlusion provides a better angiographic result,

corresponding to a better clinical outcome with fewer recurrence of symptoms and reinterventions after six months.

Am Heart J 1999 138(4 Pt 1):675-88

Long-term angiographic results of stenting in chronic total occlusions: influence of stent design and vessel size.

Escaned J, Cortes J, Alcocer MA, Goicolea J, Alfonso F, Fernandez-Ortiz A, Hernandez R, Banuelos C, Macaya C

**BACKGROUND:** Although coronary stenting has decreased the high restenosis rate associated with percutaneous transluminal coronary angioplasty of chronic total occlusions (CTOs), the results are still less satisfactory than those found in nonoccluded lesions, at least as reported with the Palmaz-Schatz stent. The present work compares the restenosis rate of other stent designs with that of the Palmaz-Schatz stent. **METHODS:** We studied the long-term angiographic outcome of 120 CTOs successfully recanalized with balloon-expandable stents and without concomitant debulking techniques. Angiographic follow-up and full quantitative coronary angiography analysis was prospectively performed in all patients. Three different stent designs were compared: Palmaz-Schatz (n = 47), coil (n = 24), and multicellular (n = 49). Particular attention was paid to their performance in vessels of 3 mm or less and greater than 3 mm in diameter. Restenosis was defined as a 50% or greater diameter stenosis at follow-up. **RESULTS:** Multicellular stents were implanted more frequently in the left anterior descending artery and in patients with multivessel disease. No other significant differences in clinical or angiographic baseline characteristics, including vessel size, were noted between groups. At follow-up, multicellular stents presented a lower restenosis rate (22% vs 36% and 58% in the Palmaz-Schatz and coil stent groups, respectively; P = .01 ) and larger minimal luminal diameters (1.92 +/- 0.85 mm vs 1.73 +/- 0.98 and 1.38 +/- 0.83 mm in the Palmaz-Schatz and coil stent groups, respectively; P = 0.0). The superiority of the multicellular stent design resulted from a lower restenosis rate in vessels of 3.0 mm or less in diameter (20% vs 47% and 79% in the Palmaz-Schatz and coil stent groups, respectively; P = .006). **CONCLUSIONS:** These results suggest that the restenosis rate after stent recanalization of CTOs is influenced by both stent design and vessel size and may indicate a superiority of multicellular over Palmaz-Schatz and coil stent designs for this purpose.

Fig. 2. Restenosis rate in CTOs recanalized with 3 different stent designs. Data for overall population and for vessels of 3.0 mm or less in diameter and 3 mm or larger are shown in separate columns.

Am J Cardiol 1999 Aug 15;84(4):386-90

Stent or angioplasty after recanalization of chronic coronary occlusions? (The SARECCO Trial).

Sievert H, Rohde S, Utech A, Schulze R, Scherer D, Merle H, Ensslen R, Schrader R, Spies H, Fach A

This study tests whether stent implantation without anticoagulation after catheter recanalization of coronary occlusions can improve outcome compared with balloon angioplasty alone. One hundred ten patients were randomly assigned to angioplasty alone (no stent group) or stent implantation (stent group) after successful recanalization and balloon angioplasty. The type of stent and angioplasty technique utilized were decided by the operator. The acute procedural success in both groups was 100%. The acute minimal lumen diameter (MLD) was 1.85 +/- 0.44 mm in the no stent group versus 2.54 +/- 0.53 mm in the stent group ( $p < 0.01$ ). The diameter stenosis was 21 +/- 13% versus 3 +/- 14% ( $p < 0.01$ ). This was achieved not only by the stent implantation itself but primarily by a larger maximum balloon diameter in the stent group after stent implantation (3.32 +/- 0.55 mm vs 2.86 +/- 0.4 mm,  $p < 0.05$ ). After 4 months, the MLD was 1.15 +/- 0.73 mm in the no stent group versus 1.81 +/- 0.9 mm in the stent group ( $p < 0.01$ ). The diameter stenosis was 56 +/- 29% versus 34 +/- 28% ( $p < 0.01$ ). After 2 years, event-free survival was 26% in the no stent group and 52% in the stent group ( $p < 0.05$ ). Thus, acute and long-term procedural and angiographic success of stent implantation without anticoagulation after recanalization of total coronary occlusions is superior to that of balloon angioplasty alone. This beneficial effect is mainly the result of the larger balloon diameters, which may be used after stent implantation.

Summary

Am J Cardiol 1999 Apr 15;83(8):1164-9

Determinants of stent restenosis in chronic coronary occlusions assessed by intracoronary ultrasound.

Werner GS, Gastmann O, Ferrari M, Scholz KH, Schunemann S, Figulla HR

Chronic coronary occlusions have a high recurrence rate that can be reduced by stenting, but this rate remains higher than in nonocclusive lesions. To analyze possible determinants of restenosis in these lesions, intracoronary ultrasound was performed during the recanalization procedure. A chronic coronary occlusion of  $>$  or  $=$  1 month duration (range 1 to 33 months; median 3.3) was successfully recanalized in 41 patients. Quantitative ultrasound analysis was performed before and after stent placement, with measurement of the luminal area, the extent of the plaque burden at the site proximal and distal to the occlusion, and within the occlusion and the subsequent stent. The degree of compensatory enlargement of the coronary artery within the occlusion was determined by comparing the average of the total vessel area of the proximal and distal reference with the lesion site. Early reocclusion (subacute stent thrombosis) was observed in 1 patient (2.4%). The angiographic control after 6 months showed restenosis in 9 patients with 1 late reocclusion. The overall recurrence rate was 24%. There was no difference in clinical and procedural characteristics between lesions with restenosis and without restenosis. The latter had a larger minimum stent area ( $7.59 \pm 1.96 \text{ mm}^2$  vs  $5.71 \pm 0.90 \text{ mm}^2$ ;  $p < 0.01$ ), and there was evidence for more compensatory vessel enlargement in lesions without restenosis. Thus, intracoronary ultrasound showed that a smaller minimum stent area was a major predictor of angiographic restenosis, and it occurred more often in occlusions without compensatory vessel enlargement.

## Summary

Cathet. Cardiovasc. Intervent. 49:45-50, 2000.

Initial experience with a hydrophilic-coated guidewire for recanalization of chronic coronary occlusions

Jan Kahler, Ralf Koster, Carsten Brockhoff, Jacobus Reimers, Stephan Baldus, Wolfram Terres, Thomas Meinertz,

Christian W. Hamm

Chronic coronary occlusions are still a therapeutic challenge to the interventional cardiologist. New techniques such as laser wire have improved recanalization rates, but outcomes are still far from satisfactory. We report the results of a nonrandomized single-center investigation using a hydrophilic-coated guidewire (Terumo Crosswire). Between September 1996 and September 1998, 107 chronic occlusions in 106 patients were approached when previous attempts with conventional guidewires failed. Median occlusion duration in these cases was 4 months (range, 0.5-122); mean occlusion length was  $19 \pm 11$  mm (range, 5-60). Forty-five (42%) of these attempts were successful. Attempts were successful in 42% in the left anterior descending artery, in 30% in the left circumflex artery, in 48% in the right coronary artery, and in 43% in coronary artery bypass grafts. Success rates ranged from 56% for occlusions of less than 4-month duration to 18% for occlusions of more than 36-month duration. The success rate in TIMI 1-flow lesions was significantly higher than in TIMI 0 flow lesions, 85% vs. 36%. In a multivariate regression analysis, TIMI flow grade and occlusion age were independent predictors of success. There were no deaths or Q-wave myocardial infarctions; two cases of hemopericardium were treated successfully. In five cases, pericardial contrast staining due to vessel perforation occurred. Our results indicate that the Crosswire is an effective tool in the treatment of chronic coronary occlusions, even when recanalization attempts with conventional guidewires fail.

The American Journal of Cardiology, 85:9:1144-1147

A randomized study comparing two guidewire strategies for angioplasty of chronic total coronary occlusion

Thierry Lefevre, Yves Louvard, Christophe Loubeyre, Pierre Dumas, Jean Francois Piechaud, Marek Krol, Abdeljabbar Benslimane, Rajendra Kumar Premchand, Marie-Claude Morice

Chronic total coronary occlusion is a relatively frequent lesion subset, and percutaneous transluminal coronary angioplasty (PTCA) in this setting is associated with lower success rates, increased costs, longer procedural duration and radiation exposure, greater use of contrast media, and higher restenosis rates compared with coronary stenosis. These limitations preclude the achievement of complete revascularization in patients with multivessel disease. For these reasons, coronary artery bypass graft surgery is frequently the first therapeutic

option in patients with multivessel disease where 1 major vessel is occluded. Despite the improvements in the techniques used, the inability to cross the lesion with the guidewire remains the most frequent cause of failure. New guidewires were recently developed in this setting, and a 0.014-in hydrophilic guide (Crosswire, Terumo, Tokyo, Japan), which was specifically designed for chronic coronary occlusion, showed encouraging preliminary results. Consequently, after a learning curve of 50 cases, we performed a randomized study.

Cathet. Cardiovasc. Intervent. 49:258-264, 2000.

Effect of plaque debulking and stenting on short-and long-term outcomes after revascularization of chronic total occlusions.

Gruberg L, Mehran R, Dangas G, Hong MK, Mintz GS, Kornowski R, Lansky AJ, Kent KM, Pichard AD, Satler LF, Stone GW, Leon MB

**OBJECTIVES:** We evaluated the effect of plaque burden modification (debulking) on the short- and long-term clinical outcomes of patients with a totally occluded native coronary artery undergoing successful stent deployment. **BACKGROUND:** Although the primary success rate of crossing a chronic totally occluded coronary artery has improved with the development of new interventional devices and guidewires, the rate of acute reocclusion and restenosis remains high. **METHODS:** The in-hospital and late clinical outcomes of 150 patients who had undergone successful stenting of 176 chronic total occlusions were analyzed. After successful crossing of the lesion, 44 patients with 50 lesions underwent debulking by laser angioplasty, rotational or directional atherectomy followed by stenting, whereas 106 patients with 126 lesions underwent stent implantation without prior debulking. **RESULTS:** Baseline clinical and angiographic characteristics were similar for the two groups, except for a higher incidence of left anterior descending coronary artery location and longer lesions in the group of patients who underwent debulking prior to stenting. In-hospital mortality, myocardial infarction and repeat angioplasty rates were similar for the two groups. At a mean 14 +/- 8 months follow-up time, there were no deaths in either group, and target lesion revascularization rates were the same (16.3% in the debulking plus stent group vs. 14.4% in the stent alone group, p = NS). **CONCLUSIONS:** Treatment of chronic total native coronary artery occlusions with stent deployment with and without lesion modification (debulking) results in a favorable in-hospital outcome, with relatively low long-term target lesion revascularization rates.

## Summary

1. In-hospital complication: No difference in mortality, myocardial infarction and TLR
2. At a mean 14 +/- 8 months follow-up time: no deaths in either group, and TLR rates were the same (16.3% in the debulking plus stent group vs. 14.4% in the stent alone group, p = NS).

Cath Cardiovasc Interv , 2000 Mar;49(3):258-64

Percutaneous transluminal coronary angioplasty of chronic total occlusions. Determinants of primary success and long-term clinical outcome

Noguchi T. Miyazaki MD S. Morii I. Daikoku S. Goto Y. Nonogi H.

This study was conducted to assess the determinants of the procedural success and long-term clinical benefits of percutaneous transluminal balloon angioplasty (PTCA) of chronic total occlusion (CTO) in recent years. Two hundred and twenty-six consecutive patients who underwent PTCA of CTO were divided into two groups according to the procedural success (n = 134) or failure (n = 92). Both groups were analyzed in terms of the initial success, predictors of procedural failure, and clinical outcome. The procedural success rate was noted to have improved to more than 70% since 1995. A multiple logistic regression analysis revealed that the presence of calcification, the length of the occlusion and the presence of multivessel disease were independent predictors of procedural failure. Cardiac death and the need for coronary surgery were significantly less frequent in patients with procedural success than in those with procedural failure. In properly selected cases, the success rate of PTCA of CTO is acceptable. Long-term clinical benefit is suggested by the high rate of freedom from coronary surgery and the low cardiac death rate in the patients who underwent successful revascularization.

Am J Cardiol 2000 Feb;85(4):487-91

Prediction of the site of total occlusion in the left anterior descending coronary artery using admission electrocardiogram in anterior wall acute myocardial infarction

Arbane M. Goy JJ.

In anterior acute myocardial infarction, ST elevation in aVL and ST depression in II, III, and aVF predict a culprit lesion in the left anterior descending artery proximal to the origin of the first diagonal branch, with good specificity and positive predictive value. Inferior ST depression is not related to remote ischemia but represents an electrocardiographic phenomenon reciprocal to ST elevation in aVL.

J Am Coll Cardiol 2000 Jul;36(1):65-8

Late total occlusion after intracoronary brachytherapy for patients with in-stent restenosis

Waksman R. Bhargava B. Mintz GS. Mehran R. Lansky AJ. Satler LF. Pichard AD. Kent KM. Leon MB

**OBJECTIVES:** The study sought to determine the incidence and predictors of late total occlusion (LTO, >30 days) in-patients with in-stent restenosis who were treated with intracoronary radiation. **BACKGROUND:** Intracoronary radiation both with beta and gamma emitters has been shown to reduce recurrent in-stent restenosis. **METHODS:** We reviewed the records of 473 patients who presented with in-stent restenosis and who were enrolled in various radiation protocols, whether randomized to placebo versus radiation or entered into registries. There were 165 placebo and 308 radiated patients, including both gamma and beta emitters. Maximum dose to the vessel wall was 30 to 55 Gy. Following radiation, all patients received antiplatelet therapy with aspirin and either ticlopidine or clopidogrel for one month. All patients completed at least six months of angiographic follow-up. **RESULTS:** The LTO was documented in 28 patients (9.1%) from the irradiated group versus 2 placebo patients (1.2%),  $p < 0.0001$ . The LTO rates were similar across studies and emitters. In the irradiated group, LTO presented as acute myocardial infarction in 12 patients (43%), unstable angina in 14 (50%), and asymptomatic in 2 (7%). Mean time to LTO was 5.4 +/- 3.2 months in the irradiated group versus 4.5 +/- 2.1 in placebo patients ( $p = \text{NS}$ ). The overall rate of restenting for the entire study group at the time of radiation was 48.6%. Importantly, new stents were placed in 82% of the irradiated and in 100% of the placebo patients who presented with LTO. Multivariate analysis determined that new stenting was the main predictor of LTO. **CONCLUSIONS:** Intracoronary radiation for patients with in-stent restenosis is associated with a high rate of LTO. Restenting may contribute late thrombosis. Prolonged antiplatelet therapy (up to six months) should be considered for these patients

Summary

Table 2. Clinical, Procedural, and Angiographic Findings in 28 Patients Who Received Brachytherapy for In-stent Restenosis and Who Presented With Late Total Occlusion

Total occlusion

1. Predictors of improvement in left ventricular function after percutaneous revascularization of occluded coronary arteries: a report from the Total Occlusion Study of Canada (TOSCA).

Dzavik V, Carere RG, Mancini GB, Cohen EA, Catellier D, Anderson TE, Barbeau G, Lazzam C, Title LM, Berger PB, Labinaz M, Teo KK, Buller CE; The Total Occlusion Study of Canada Investigators.

Am Heart J 2001 Aug;142(2):301-8

2. Procedural outcomes and long-term survival among patients undergoing percutaneous coronary intervention of a chronic total occlusion in native coronary arteries: a 20-year experience.

Suero JA, Marso SP, Jones PG, Laster SB, Huber KC, Giorgi LV, Johnson WL, Rutherford BD.

J Am Coll Cardiol 2001 Aug;38(2):409-14

3. Microvascular dysfunction in chronic total coronary occlusions.

Werner GS, Ferrari M, Richartz BM, Gastmann O, Figulla HR.

Circulation 2001 Sep 4;104(10):1129-34

4. Influence on collateral flow of recanalising chronic total coronary occlusions: a case-control study.

Pohl T, Hochstrasser P, Billinger M, Fleisch M, Meier B, Seiler C.

Heart 2001 Oct;86(4):438-43

5. Noninvasive detection of total occlusion of the left anterior descending coronary artery with transthoracic Doppler echocardiography.

Watanabe N, Akasaka T, Yamaura Y, Akiyama M, Koyama Y, Kamiyama N, Neishi Y, Kaji S, Saito Y, Yoshida K.

J Am Coll Cardiol 2001 Nov 1;38(5):1328-32

6. Does ticlopidine reduce reocclusion and other adverse events after successful balloon angioplasty of occluded coronary arteries? Results from the Total Occlusion Study of Canada (TOSCA).

Berger PB, Dzavik V, Penn IM, Catellier D, Buller CE.

Am Heart J 2001 Nov;142(5):776-81

7. Collateral function in chronic total coronary occlusions is related to regional myocardial function and duration of occlusion.

Werner GS, Ferrari M, Betge S, Gastmann O, Richartz BM, Figulla HR.

Circulation 2001 Dec 4;104(23):2784-90

8. Collateral function in chronic total coronary occlusions is related to regional myocardial function and duration of occlusion.

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