

Clinical and economic outcomes of multivessel coronary stenting compared with bypass surgery: a single-center US experience.

Reynolds MR, Neil N, Ho KK, Berezin R, Cosgrove RS, Lager RA, Sirois C, Johnson RG, Cohen DJ.

BACKGROUND: Randomized trials comparing multivessel stenting with coronary artery bypass surgery (CABG) have demonstrated similar rates of death and myocardial infarction but higher rates of repeat revascularization after stenting. The impact of these alternative strategies on overall medical care costs is uncertain, particularly within the US health care system. METHODS: We performed a retrospective, matched cohort study to compare the clinical and economic outcomes of multivessel stenting and bypass surgery. The stent group consisted of 100 consecutive patients who underwent stenting of ≥ 2 major native coronary arteries at our institution. The CABG group consisted of 200 patients who underwent nonemergent isolated bypass surgery during the same time frame, matched (2:1) for age, sex, ejection fraction, diabetes mellitus, and extent of coronary disease. Detailed clinical follow-up and resource utilization data were collected for a minimum of 2 years. Total costs were calculated by use of year 2000 unit prices. RESULTS: Over a median follow up period of 2.8 years, there were no significant differences in all-cause mortality rates (3.0% vs 3.0%), Q-wave myocardial infarction (5.1% vs 4.0%), or the composite of death or myocardial infarction (7.1% vs 7.0%) between the stent and CABG groups ($P =$ not significant for all comparisons). However, at 2-year follow up, patients with stents were more likely to require ≥ 1 repeat revascularization procedure (32.0% vs 4.5%, $P < .001$). The initial cost of multivessel stenting was 43% less than the cost of CABG (11,810 dollars vs 20,574 dollars, $P < .001$) and remained 27% less (17,634 dollars vs 24,288 dollars, $P = .005$) at 2 years. CONCLUSIONS: Multivessel stenting and CABG result in comparable risks of death and myocardial infarction. Despite a higher rate of repeat revascularization, multivessel stenting was significantly less costly than CABG through the first 2 years of follow-up.

Coronary stenting versus coronary bypass surgery in patients with multiple vessel disease and significant proximal LAD stenosis: results from the ERACI II study.

Rodriguez A, Rodriguez Alemparte M, Baldi J, Navia J, Delacasa A, Vogel D, Oliveri R, Fernandez Pereira C, Bernardi V, O'Neill W, Palacios IF.

PURPOSE: To compare percutaneous coronary intervention (PCI) using stent implantation versus coronary artery bypass graft (CABG) in patients with multiple vessel disease with involvement of the proximal left anterior descending coronary artery (LAD). **METHODS:** 230 patients with multiple vessel disease and severe stenosis of the proximal LAD (113 with PCI, 117 with CABG). They were a cohort of patients from the randomised ERACI (Argentine randomized trial of percutaneous transluminal coronary angioplasty versus coronary artery bypass surgery in multivessel disease) II study. **RESULTS:** Both groups had similar baseline characteristics. There were no significant differences in 30 day major adverse cardiac events (death, myocardial infarction, stroke, and repeat procedures) between the strategies (PCI 2.7% v CABG 7.6%, $p = 0.18$). There were no significant differences in survival (PCI 96.4% v CABG 95%, $p = 0.98$) and survival with freedom from myocardial infarction (PCI 92% v CABG 89%, $p = 0.94$) at 41.5 (6) months' follow up. However, freedom from new revascularisation procedures (CABG 96.6% v PCI 73%, $p = 0.0002$) and frequency of angina (CABG 9.4% v PCI 22%, $p = 0.025$) were superior in the CABG group. **CONCLUSION:** Patients with multivessel disease and significant disease of the proximal LAD randomly assigned in the ERACI II trial to PCI or CABG had similar survival and survival with freedom from myocardial infarction at long term follow up. Repeat revascularisation procedures were higher in the PCI group.

Outcomes of repeat revascularization in diabetic patients with prior coronary surgery.

Cole JH, Jones EL, Craver JM, Guyton RA, Morris DC, Douglas JS, Ghazzal Z, Weintraub WS.

OBJECTIVES: This study evaluated both short- and long-term outcomes of diabetic patients who underwent repeat coronary artery bypass graft surgery (CABG) or percutaneous coronary intervention (PCI) after initial CABG. **B**ACKGROUND: Although diabetic patients who have multivessel coronary disease and require initial revascularization may benefit from CABG as compared with PCI, the uncertainty concerning the choice of revascularization may be greater for diabetic patients who have had previous CABG. **M**ETHODS: Data were obtained over 15 years for diabetic patients undergoing PCI procedures or repeat CABG after previous coronary surgery. Baseline characteristics were compared between groups, and in-hospital, 5-year, and 10-year mortality rates were calculated. Multivariate correlates of in-hospital and long-term mortality were determined. **R**ESULTS: Both PCI (n = 1,123) and CABG (n = 598) patients were similar in age, gender, years of diabetes, and insulin dependence, but they varied in presence of hypertension, prior myocardial infarction, angina severity, heart failure, ejection fraction, and left main disease. In-hospital mortality was greater for CABG, but differences in long-term mortality were not significant (10 year mortality, 68% PCI vs. 74% CABG, p = 0.14). Multivariate correlates of long-term mortality were older age, hypertension, low ejection fraction, and an interaction between heart failure and choice of PCI. The PCI itself did not correlate with mortality. **C**ONCLUSIONS: The increased initial risk of redo CABG in diabetic patients and the comparable high long-term mortality regardless of type of intervention suggest that, except for patients with severe heart failure, PCI be strongly considered in all patients for whom there is a percutaneous alternative.

Percutaneous transluminal coronary angioplasty in 1980-85 and 1995-96: more frequent multivessel disease, fewer reoperations and no change in mortality 1 and 5 years postoperatively

van Domburg RT, Vos J, Serruys PW.

OBJECTIVE: To describe the characteristics of patients undergoing coronary angioplasty (PTCA) over the past 20 years and the outcome after 1 and 5 years. DESIGN: Prospective follow-up study. METHODS: All patients who underwent a first PTCA in the Thorax centre of the Erasmus Medical Centre in Rotterdam during the period from 1 September 1980 through 30 November 1985 (group I) were compared with all patients who likewise underwent such a first PTCA during the period between 1 September 1995 and 31 December 1996 (group II). Data on the patients, the operations, any reoperations and the mortality were obtained from patient records, general practitioners and municipal archives. Cumulative percentages of survival and of not having rePTCA or coronary artery bypass surgery (CABG) were analysed by using the Kaplan-Meier-method. RESULTS: Group I consisted of 856 patients and group II of 840 patients. The percentage of males decreased over the years from 80% to 69%. The average age increased from 56 to 60 years; the oldest patient in group I was 75 years and the oldest in group II was 87 years. The percentage of patients with multivessel disease increased from 36% to 44%. Stent implantation occurred in 55% of the patients in group II (0% in group I). The necessity for urgent CABG due to unsuccessful PTCA decreased from 9.4% to 1%. After 1 year, the percentage of coronary revascularisations was 28.8% in group I and 22.6% in group II ($p = 0.01$). The perioperative mortality and the 5-year survival were not significantly different in the two groups (group I: 1.3% and 90%; group II: 2.4% and 88%, respectively). For both groups, higher age, a smaller ejection fraction, more extensive vascular disease and no treatment with statins were independent predictors of a higher mortality after 5 years. In group II, renal function disorders were the most important predictor of higher mortality.

Hybrid robotic coronary artery surgery and angioplasty in multivessel coronary artery disease.

Stahl KD, Boyd WD, Vassiliades TA, Karamanoukian HL.

BACKGROUND: Complete surgical revascularization that includes left internal thoracic artery grafting to the left anterior descending coronary artery remains the gold standard of treatment for coronary artery disease. Not all patients are good candidates for sternotomy. Therefore, we sought to identify a strategy that would combine the long-term advantages of internal thoracic artery grafting to lessen surgical trauma while still allowing complete revascularization. METHODS: A total of 54 consecutive patients from four institutions underwent hybrid revascularization combining surgery and angioplasty. All internal thoracic artery grafts were endoscopically harvested with robotic assistance using either the Aesop or Zeus system, and all anastomoses were manually constructed through a 4- to 6-cm anterior thoracotomy incision. Angioplasty was carried out to achieve total revascularization to ungrafted vessels. RESULTS: There were no early or late deaths, myocardial infarctions, strokes, or wound infections. Of the patients, 37 (69%) were extubated in the operating room. Length of stay in the intensive care unit averaged 24.4 hours and hospital stay 3.45 days. In all, 16 patients (29.6%) required transfusion of packed red blood cells. Late complications included 1 patient with stent occlusion at 3 months and 2 patients with in-stent restenosis. Three patients were treated for postpericardiotomy syndrome. Mean follow-up was 11.7 months. Event-free survival was 87.1% and freedom from recurrent angina 98.3%. CONCLUSIONS: Hybrid endoscopic atraumatic internal thoracic artery to anterior descending coronary artery graft surgery combined with angioplasty is a reasonable revascularization strategy in multiple vessel coronary artery disease in selected patients. Longer follow-up and more patient data in a randomized study are needed to determine the patient cohort most likely to benefit from this approach.

Coronary artery bypass surgery versus percutaneous coronary intervention with stent implantation in patients with multivessel coronary artery disease (the Stent or Surgery trial): a randomised controlled trial.

SoS Investigators.

BACKGROUND: Results of trials, comparing percutaneous transluminal coronary angioplasty (PTCA) with coronary artery bypass grafting (CABG), indicate that rates of death or myocardial infarction are similar with either treatment strategy. Management with PTCA is, however, associated with an increased requirement for subsequent, additional revascularisation. Coronary stents, used as an adjunct to PTCA, reduce restenosis and the need for repeat revascularisation. The aim of the Stent or Surgery (SoS) trial was to assess the effect of stent-assisted percutaneous coronary intervention (PCI) versus CABG in the management of patients with multivessel disease. **METHODS:** In 53 centres in Europe and Canada, symptomatic patients with multivessel coronary artery disease were randomised to CABG (n=500) or stent-assisted PCI (n=488). The primary outcome measure was a comparison of the rates of repeat revascularisation. Secondary outcomes included death or Q-wave myocardial infarction and all-cause mortality. Analysis was by intention to treat. **FINDINGS:** All patients were followed-up for a minimum of 1 year and the results are expressed for the median follow-up of 2 years. 21% (n=101) of patients in the PCI group required additional revascularisation procedures compared with 6% (n=30) in the CABG group (hazard ratio 3.85, 95% CI 2.56-5.79, $p < 0.0001$). The incidence of death or Q-wave myocardial infarction was similar in both groups (PCI 9% [n=46], CABG 10% [n=49]; hazard ratio 0.95, 95% CI 0.63-1.42, $p = 0.80$). There were fewer deaths in the CABG group than in the PCI group (PCI 5% [n=22], CABG 2% [n=8]; hazard ratio 2.91, 95% CI 1.29-6.53, $p = 0.01$). **INTERPRETATION:** The use of coronary stents has reduced the need for repeat revascularisation when compared with previous studies that used balloon angioplasty, though the rate remains significantly higher than in patients managed with CABG. The apparent reduction in mortality with CABG requires further investigation.

Contemporary percutaneous coronary intervention versus balloon angioplasty for multivessel coronary artery disease: a comparison of the National Heart, Lung and Blood Institute Dynamic Registry and the Bypass Angioplasty Revascularization Investigation (BARI) study.

Srinivas VS, Brooks MM, Detre KM, King SB 3rd, Jacobs AK, Johnston J, Williams DO.

BACKGROUND: This investigation compares the results of contemporary percutaneous coronary intervention (PCI) with standard balloon angioplasty among patients with multivessel coronary disease. Patients having balloon angioplasty in the Bypass Angioplasty Revascularization Investigation (BARI) and those within the Dynamic Registry meeting BARI eligibility criteria were studied. **METHODS AND RESULTS:** Clinical features and in-hospital and 1-year outcomes of 857 BARI-eligible patients in the Dynamic Registry (contemporary PCI) were compared with the 904 randomized patients who underwent percutaneous transluminal coronary angioplasty in BARI. Compared with BARI patients, Registry patients had fewer lesions attempted (1.53 versus 2.56, $P=0.001$), more frequent single-vessel PCI (76% versus 33%, $P<0.001$), greater use of intracoronary stents (76% versus 1%, $P<0.001$), and GP IIb/IIIa receptor antagonist (24% versus 0%, $P<0.001$). Angiographic success was achieved more often among Registry patients (91% versus 72%, $P<0.001$), whereas abrupt closure (1.5% versus 9.5%, $P<0.001$) and in-hospital coronary artery bypass graft (CABG) (1.9% versus 10.2%, $P<0.001$) and myocardial infarction (0.8% versus 2.1%, $P=0.025$) were less common. No differences were observed in either in-hospital or 1-year death, but 1-year death/myocardial infarction was lower in the Registry. Registry patients had lower 1-year rates of subsequent CABG (8.6% versus 22.7%, $P<0.001$) and PCI (12.4% versus 22.5%, $P<0.001$). By multivariate analysis, contemporary PCI was independently associated with reduced risk for in-hospital CABG, 1-year CABG, and 1-year PCI. **CONCLUSIONS:** Among patients with multivessel disease, contemporary PCI resulted in safer and more durable revascularization. These results support the role of PCI for selected patients with multivessel coronary artery disease.

Percutaneous stent implantation for treating multivessel coronary disease in patients with and without involvement of the proximal segment of the anterior descending coronary artery.

Salgueiro S, Silva AD, Tofano RJ, Costa VC, Pizarro K, Salman AA, Mangione JA.

OBJECTIVE: To assess coronary stent placement in patients with multivessel coronary disease and involvement of the proximal portion of the anterior descending coronary artery. METHODS: We retrospectively analyzed the in-hospital and late evolution of 189 patients with multivessel coronary disease, who underwent percutaneous coronary stent placement. These patients were divided into 2 groups as follows: group I (GI) - 59 patients with involvement of the proximal segment of the anterior descending coronary artery; and group II (GII) - 130 patients without involvement of the proximal segment of the anterior descending coronary artery. RESULTS: No significant difference was observed in the success rate of the procedure (91.5% versus 97.6%, $p=0.86$), nor in the occurrence of major adverse cardiac events (5.1% versus 1.5%, $p=0.38$), nor in the occurrence of major vascular complications (1.7% versus 0%, $p=0.69$) in the in-hospital phase. In the late follow-up, the incidence of major adverse cardiac events (15.4% versus 13.7%, $p=0.73$) and the need for new revascularization (13.5% versus 10.3%, $p=0.71$) were similar for both groups. CONCLUSION: The in-hospital and late evolution of patients with multivessel coronary disease with and without involvement of the proximal segment of the anterior descending coronary artery treated with coronary stent placement did not differ. This suggests that this revascularization method is an effective procedure and a valuable option for treating these types of patients.

Staged versus one-step approach for multivessel percutaneous coronary interventions.

Nikolsky E, Halabi M, Roguin A, Zdrovyak A, Gruberg L, Hir J, Grenadier E, Boulos M, Markiewicz W, Linn S, Beyar R.

BACKGROUND: Percutaneous coronary interventions (PCIs) in patients with multivessel coronary artery disease (CAD) may be staged or performed in a single session. No data exist about the relative safety and efficacy of these 2 strategies. Our aim was to compare short-term and long-term outcomes of patients with multivessel CAD who underwent PCI in 1 versus 2 sessions. **METHODS AND RESULTS:** The study included 264 consecutive patients who underwent treatment in our center during 1997 and 1998. PCI was conducted in a single session in 129 patients and was staged in 135 patients. The mean interval between the sessions in the staged group was 45.6 +/- 22.3 days. The rates of major adverse cardiac events (MACEs) during in-hospital stay did not differ significantly between the staged (combined for both stages) and nonstaged groups (2.2% vs 4.6%; P =.28). A trend for lower event rates at 30-day (2.9% vs 6.9%; P =.13) and 1-year follow-up (26.1 vs 35.9; P =.08) favored the staged arm. Diameter stenosis > or =50% was found in 17% of patients in the staged group in the second session and was successfully retreated in most of them. No MACE occurred between the sessions. Multivariate analysis identified staging of the procedure as a single independent predictor of MACE at 1-year follow-up (P =.05). **CONCLUSION:** Our results suggest that a practical staging strategy within 4 to 8 weeks is safe and allows for identification and treatment of potential excessive proliferative response in the previously intervened lesions during the second procedure.

Percutaneous revascularization of multivessel coronary disease using stents - a multicenter, prospective study

Baldus S, Koster R, Kuchler R, v Dahl J, Dietz U, Voelker W, Reimers J, Kuck KH, Sasse A, Rupprecht JH, Sieburg B, Meyer J, Berger J, Meinertz T, Hamm CW.

BACKGROUND AND OBJECTIVE: Symptomatic patients with multivessel coronary disease (MVD) benefit from both coronary artery bypass grafting (CABG) and percutaneous coronary angioplasty (PTCA). The >>German Angioplasty Bypass Investigation<< (GABI-I) trial randomized patients to one of these treatment strategies between 1986 and 1991. In order to evaluate the impact of current technology, in particular coronary stents, the GABI-II trial was initiated, which in 1996 and 1997 prospectively enrolled patients according to the initial GABI-I criteria. PATIENTS AND METHODS: Into the study 136 consecutive patients (108 men, 28 women; 63 +/- 12 years) were included. Patients from GABI-I served as controls. RESULTS: A mean of 2.1 +/- 0.5 vessels were treated per patient (vs. 1.9 +/- 0.5 vessels in the PTCA arm of GABI-I) and 63 % of the lesions were covered with stents. With respect to the primary endpoint less patients remained with a CCS class III or IV in GABI-II after 12 months (1,5 % vs. 8 % in the PTCA arm of GABI-I, $p < 0,01$). No patient required emergency or urgent bypass operation in GABI-II (vs. 9 % in GABI-I, $p < 0,01$). After 12 months, 8 % of the patients were sent for bypass surgery (CABG) vs. 21 % in GABI-I ($p < 0,001$), and 20 % (vs. 23 % in GABI-I) of the patients underwent Re-PTCA. The percentage of patients without reinterventions was 72 % vs. 56 % in GABI-I ($p < 0,01$), but remained lower compared to patients randomized to CABG in GABI-I (94 %, $p < 0,001$). CONCLUSION: PTCA in patients with MVD is still associated with a higher reintervention rate as compared with CABG. However, in contrast to angioplasty a decade ago, PTCA in conjunction with stents significantly lowered the need for subsequent revascularization, which was mainly driven by the reduced necessity for bypass surgery.

Prognostic value of coronary blood flow velocity and myocardial perfusion in intermediate coronary narrowings and multivessel disease.

Chamuleau SA, Tio RA, de Cock CC, de Muinck ED, Pijls NH, van Eck-Smit BL, Koch KT, Meuwissen M, Dijkgraaf MG, de Jong A, Verberne HJ, van Liebergen RA, Laarman GJ, Tijssen JG, Piek JJ.

OBJECTIVES: This study aimed to investigate the roles of intracoronary derived coronary flow velocity reserve (CFVR) and myocardial perfusion scintigraphy (single photon emission computed tomography, or SPECT) for management of an intermediate lesion in patients with multivessel coronary artery disease. **BACKGROUND:** Evaluation of the functional significance of intermediate coronary narrowings (40% to 70% diameter stenosis) is important for clinical decision making and risk stratification. **METHODS:** In a prospective, multicenter study, SPECT was performed in 191 patients with stable angina and multivessel disease and scheduled for angioplasty (percutaneous transluminal coronary angioplasty, or PTCA) of a severe coronary narrowing. Coronary flow velocity reserve was determined selectively distal to an intermediate lesion in another artery using a Doppler guidewire. Percutaneous transluminal coronary angioplasty of the intermediate lesion was deferred when SPECT was negative or CFVR greater-than-or-equal 2.0. Patients were followed for one year to document major cardiac events (death, infarction, revascularization), related to the intermediate lesion. **RESULTS:** Reversible perfusion defects were documented in the area of the intermediate lesion in 30 (16%) patients; CFVR was positive in 46 (24%) patients. Percutaneous transluminal coronary angioplasty of the intermediate lesion was deferred in 182 patients. During follow-up, 19 events occurred (3 myocardial infarctions, 16 revascularizations). Coronary flow velocity reserve was a more accurate predictor of cardiac events than was SPECT; relative risk: CFVR 3.9 (1.7 to 9.1), $p < 0.05$; SPECT 0.5 (0.1 to 3.2), $p = \text{NS}$. Multivariate analysis revealed CFVR as the only significant predictor for cardiac events. **CONCLUSIONS:** Deferral of PTCA of intermediate lesions in multivessel disease is safe when CFVR greater-than-or-equal 2.0 (event rate 6%). This selective evaluation of coronary lesion severity during cardiac catheterization allows a more accurate risk stratification than does SPECT, which is important for clinical decision making in this patient cohort.

MULTIVESSEL PTCA

1. Clinical and economic outcomes of multivessel coronary stenting compared with bypass surgery: a single-center US experience.

Reynolds MR, Neil N, Ho KK, Berezin R, Cosgrove RS, Lager RA, Sirois C, Johnson RG, Cohen DJ.
Am Heart J 2003 Feb;145(2):334-42

2. Coronary stenting versus coronary bypass surgery in patients with multiple vessel disease and significant proximal LAD stenosis: results from the ERACI II study.

Rodriguez A, Rodriguez Alemparte M, Baldi J, Navia J, Delacasa A, Vogel D, Oliveri R, Fernandez Pereira C, Bernardi V, O'Neill W, Palacios IF.
Heart 2003 Feb;89(2):184-8

3. Outcomes of repeat revascularization in diabetic patients with prior coronary surgery.

Cole JH, Jones EL, Craver JM, Guyton RA, Morris DC, Douglas JS, Ghazzal Z, Weintraub WS.
J Am Coll Cardiol 2002 Dec 4;40(11):1968-75

4. Percutaneous transluminal coronary angioplasty in 1980-85 and 1995-96: more frequent multivessel disease, fewer reoperations and no change in mortality 1 and 5 years postoperatively
van Domburg RT, Vos J, Serruys PW.

Ned Tijdschr Geneeskd 2002 Nov 16;146(46):2196-200

5. Hybrid robotic coronary artery surgery and angioplasty in multivessel coronary artery disease.

Stahl KD, Boyd WD, Vassiliades TA, Karamanoukian HL.
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6. Coronary artery bypass surgery versus percutaneous coronary intervention with stent implantation in patients with multivessel coronary artery disease (the Stent or Surgery trial): a randomised controlled trial. SoS Investigators.

Lancet 2002 Sep 28;360(9338):965-70

7. Contemporary percutaneous coronary intervention versus balloon angioplasty for multivessel coronary artery disease: a comparison of the National Heart, Lung and Blood Institute Dynamic Registry and the Bypass Angioplasty Revascularization Investigation (BARI) study.

Srinivas VS, Brooks MM, Detre KM, King SB 3rd, Jacobs AK, Johnston J, Williams DO.
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8. Percutaneous stent implantation for treating multivessel coronary disease in patients with and without involvement of the proximal segment of the anterior descending coronary artery.

Salgueiro S, Silva AD, Tofano RJ, Costa VC, Pizarro K, Salman AA, Mangione JA.
Arq Bras Cardiol 2002 Jul;79(1):25-34

9. Staged versus one-step approach for multivessel percutaneous coronary interventions.

Nikolsky E, Halabi M, Roguin A, Zdoroviyak A, Gruberg L, Hir J, Grenadier E, Boulos M, Markiewicz W, Linn S, Beyar R.

Am Heart J 2002 Jun;143(6):1017-26

10. Percutaneous revascularization of multivessel coronary disease using stents - a multicenter, prospective study

Baldus S, Koster R, Kuchler R, v Dahl J, Dietz U, Voelker W, Reimers J, Kuck KH, Sasse A, Rupprecht JH, Sieburg B, Meyer J, Berger J, Meinertz T, Hamm CW.

Dtsch Med Wochenschr 2002 Mar 15;127(11):547-52

11. Prognostic value of coronary blood flow velocity and myocardial perfusion in intermediate coronary narrowings and multivessel disease.

Chamuleau SA, Tio RA, de Cock CC, de Muinck ED, Pijls NH, van Eck-Smit BL, Koch KT, Meuwissen M, Dijkgraaf MG, de Jong A, Verberne HJ, van Liebergen RA, Laarman GJ, Tijssen JG, Piek JJ.

J Am Coll Cardiol 2002 Mar 6;39(5):852-8

N Engl J Med 2001 Apr 12;344(15):1117-24

Comparison of coronary-artery bypass surgery and stenting for the treatment of multivessel disease.

Serruys PW, Unger F, Sousa JE, Jatene A, Bonnier HJ, Schonberger JP, Buller N, Bonser R, van den Brand MJ, van Herwerden LA, Morel MA, van Hout BA

BACKGROUND: The recent recognition that coronary-artery stenting has improved the short- and long-term outcomes of patients treated with angioplasty has made it necessary to reevaluate the relative benefits of bypass surgery and percutaneous interventions in patients with multivessel disease. **METHODS:** A total of 1205 patients were randomly assigned to undergo stent implantation or bypass surgery when a cardiac surgeon and an interventional cardiologist agreed that the same extent of revascularization could be achieved by either technique. The primary clinical end point was freedom from major adverse cardiac and cerebrovascular events at one year. The costs of hospital resources used were also determined. **RESULTS:** At one year, there was no significant difference between the two groups in terms of the rates of death, stroke, or myocardial infarction. Among patients who survived without a stroke or a myocardial infarction, 16.8 percent of those in the stenting group underwent a second revascularization, as compared with 3.5 percent of those in the surgery group. The rate of event-free survival at one year was 73.8 percent among the patients who received stents and 87.8 percent among those who underwent bypass surgery ($P < 0.001$ by the log-rank test). The costs for the initial procedure were \$4,212 less for patients assigned to stenting than for those assigned to bypass surgery, but this difference

was reduced during follow-up because of the increased need for repeated revascularization; after one year, the net difference in favor of stenting was estimated to be \$2,973 per patient. CONCLUSION: As measured one year after the procedure, coronary stenting for multivessel disease is less expensive than bypass surgery and offers the same degree of protection against death, stroke, and myocardial infarction. However, stenting is associated with a greater need for repeated revascularization.

Am J Cardiol 2001 Jul 15;88(2):170-3, A6

Initial experience with multivessel percutaneous coronary intervention during mechanical reperfusion for acute myocardial infarction.

Roe MT, Cura FA, Joski PS, Garcia E, Guetta V, Kereiakes DJ, Zijlstra F, Brodie BR

The feasibility and safety of simultaneous multivessel percutaneous coronary intervention during mechanical reperfusion for acute myocardial infarction was analyzed in a retrospective, case-controlled study. Patients who underwent multivessel coronary intervention had a higher risk of adverse clinical outcomes through 6 months compared with matched controls in whom coronary intervention was limited to the infarct-related artery.

Circulation 2001 Jul 31;104(5):533-8

Clinical and economic impact of diabetes mellitus on percutaneous and surgical treatment of multivessel coronary disease patients: insights from the Arterial Revascularization Therapy Study (ARTS) trial.

Abizaid A, Costa MA, Centemero M, Abizaid AS, Legrand VM, Limet RV, Schuler G, Mohr FW, Lindeboom W, Sousa AG, Sousa JE, van Hout B, Hugenholtz PG, Unger F, Serruys PW; Arterial Revascularization Therapy Study Group

BACKGROUND: Our aims were to compare coronary artery bypass grafting (CABG) and stenting for the

treatment of diabetic patients with multivessel coronary disease enrolled in the Arterial Revascularization Therapy Study (ARTS) trial and to determine the costs of these 2 treatment strategies. METHODS AND RESULTS: Patients (n=1205) were randomly assigned to stent implantation (n=600; diabetic, 112) or CABG (n=605; diabetic, 96). Costs per patient were calculated as the product of each patient's use of resources and the corresponding unit costs. Baseline characteristics were similar between the groups. At 1 year, diabetic patients treated with stenting had the lowest event-free survival rate (63.4%) because of a higher incidence of repeat revascularization compared with both diabetic patients treated with CABG (84.4%, $P<0.001$) and nondiabetic patients treated with stents (76.2%, $P=0.04$). Conversely, diabetic and nondiabetic patients experienced similar 1-year event-free survival rates when treated with CABG (84.4% and 88.4%). The total 1-year costs for stenting and CABG in diabetic patients were \$12 855 and \$16 585 ($P<0.001$) and in the nondiabetic groups, \$10 164 for stenting and \$13 082 for surgery. CONCLUSIONS: Multivessel diabetic patients treated with stenting had a worse 1-year outcome than patients assigned to CABG or nondiabetics treated with stenting. The strategy of stenting was less costly than CABG, however, regardless of diabetic status

Am Heart J 2001 Jul;142(1):119-26

Long-term survival in 11,661 patients with multivessel coronary artery disease in the era of stenting: a report from the Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease (APPROACH) Investigators.

Dzavik V, Ghali WA, Norris C, Mitchell LB, Koshal A, Saunders LD, Galbraith PD, Hui W, Faris P, Knudtson ML; Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease (APPROACH) Investigators

BACKGROUND: Studies of survival of patients with multivessel coronary artery disease (MVD) in the present era suggested that outcomes after coronary artery bypass surgery (CABG) are similar to those after percutaneous coronary intervention (PCI) in subsets of coronary severity. The purpose of this study of the Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease (APPROACH) was to examine the association between treatment and survival up to 5 years in patients with MVD enrolled from 1995 through 1998. METHODS AND RESULTS: Data on patient characteristics were obtained at the time of the initial coronary angiography. Survival was determined through data linkage to the provincial Bureau of Vital Statistics. Risk-adjusted hazard ratios were calculated to compare different treatments. In the 11,661 patients with MVD, CABG was the initial therapy in 3782, PCI in 3540, and medical therapy in 4339. Cumulative 5-year survival was 91.4% with CABG, 91.9% with PCI, and 82.9% with medical therapy ($P<0.001$). Hazard ratios were CABG: medical 0.53 (95% confidence interval [CI] 0.46-0.71), PCI: medical 0.65 (95% CI 0.56-0.74), and CABG: PCI 0.81 (95% CI 0.68-0.96). Analysis across coronary severity groups revealed a benefit of CABG compared

with PCI only in the group with severe left main CAD: 0.30 (95% CI 0.17-0.54). CONCLUSIONS: In a multicenter clinical setting, MVD patients treated with revascularization have significantly higher 5-year survival rate than do those treated medically. Risk-adjusted comparison reveals PCI treatment to be associated with long-term survival similar to treatment with CABG in all coronary severity subgroups except the group with severe left main coronary artery disease. Patient selection factors are likely to be contributing to these findings.

Circulation 2002 Feb 26;105(8):987-92

Perfusion versus function: the ischemic cascade in demand ischemia: implications of single-vessel versus multivessel stenosis.

Leong-Poi H, Rim SJ, Le DE, Fisher NG, Wei K, Kaul S

BACKGROUND: We hypothesized that during demand ischemia, abnormal perfusion will precede abnormal function, the spatial extent of perfusion abnormality will be greater than that of functional abnormality, and the spatiotemporal disparity between abnormal perfusion and abnormal function will be more marked in the presence of single-vessel stenosis (SVS) versus multivessel stenosis (MVS). METHODS AND RESULTS: Nine dogs each underwent either SVS or MVS placement. These noncritical stenoses were classified as mild, moderate, or severe on the basis of the transstenotic pressure gradient (10 to 14, 15 to 20, or >20 mm Hg). Dobutamine was infused starting at 10 and reaching 40 microg/kg(-1) x min(-1). Wall thickening (WT) and myocardial perfusion (myocardial contrast echocardiography) were assessed at each stage. Resting perfusion and function were normal in all dogs. In SVS, abnormal perfusion (delayed rate of microbubble replenishment) was seen at the lowest dose of dobutamine irrespective of the stenosis severity, whereas WT abnormality was seen only at high doses of dobutamine and was influenced by the stenosis severity. The spatial extent of abnormal perfusion exceeded that of WT abnormality at all but the highest dobutamine dose. This spatiotemporal discordance between abnormal perfusion and function was significantly less in MVS, where it was possible to identify separate regions with abnormal function at lower doses of dobutamine. CONCLUSIONS: These data support the occurrence of the ischemic cascade during demand ischemia. They also explain the higher sensitivity of abnormal perfusion compared with abnormal function for the detection of coronary stenosis as well as the higher sensitivity of dobutamine echocardiography for MVS compared with SVS.

J Am Coll Cardiol 2002 Mar 6;39(5):852-8

Prognostic value of coronary blood flow velocity and myocardial perfusion in intermediate coronary narrowings and multivessel disease.

Chamuleau SA, Tio RA, de Cock CC, de Muinck ED, Pijls NH, van Eck-Smit BL, Koch KT, Meuwissen M, Dijkgraaf MG, de Jong A, Verberne HJ, van Liebergen RA, Laarman GJ, Tijssen JG, Piek JJ.

This study aimed to investigate the roles of intracoronary derived coronary flow velocity reserve (CFVR) and myocardial perfusion scintigraphy (single photon emission computed tomography, or SPECT) for management of an intermediate lesion in patients with multivessel coronary artery disease. Evaluation of the functional significance of intermediate coronary narrowings (40% to 70% diameter stenosis) is important for clinical decision making and risk stratification. In a prospective, multicenter study, SPECT was performed in 191 patients with stable angina and multivessel disease and scheduled for angioplasty (percutaneous transluminal coronary angioplasty, or PTCA) of a severe coronary narrowing. Coronary flow velocity reserve was determined selectively distal to an intermediate lesion in another artery using a Doppler guidewire. Percutaneous transluminal coronary angioplasty of the intermediate lesion was deferred when SPECT was negative or CFVR greater-than-or-equal 2.0. Patients were followed for one year to document major cardiac events (death, infarction, revascularization), related to the intermediate lesion. Reversible perfusion defects were documented in the area of the intermediate lesion in 30 (16%) patients; CFVR was positive in 46 (24%) patients. Percutaneous transluminal coronary angioplasty of the intermediate lesion was deferred in 182 patients. During follow-up, 19 events occurred (3 myocardial infarctions, 16 revascularizations). Coronary flow velocity reserve was a more accurate predictor of cardiac events than was SPECT; relative risk: CFVR 3.9 (1.7 to 9.1), $p < 0.05$; SPECT 0.5 (0.1 to 3.2), $p = \text{NS}$. Multivariate analysis revealed CFVR as the only significant predictor for cardiac events. Deferral of PTCA of intermediate lesions in multivessel disease is safe when CFVR greater-than-or-equal 2.0 (event rate 6%). This selective evaluation of coronary lesion severity during cardiac catheterization allows a more accurate risk stratification than does SPECT, which is important for clinical decision making in this patient cohort.

N Engl J Med 1996;335:217-25

Comparison of Coronary Bypass Surgery with Angioplasty in Patients with Multivessel Disease

The Bypass Angioplasty Revascularization Investigation (BARI) Investigators

Background. Coronary-artery bypass grafting (CABG) and percutaneous transluminal coronary angioplasty (PTCA) are alternative methods of revascularization in patients with coronary artery disease. We tested the hypothesis that in selected patients with multivessel disease suitable for treatment with either procedure, an initial strategy of PTCA does not result in a poorer five-year clinical outcome than CABG.

Methods. Patients with multivessel disease were randomly assigned to an initial treatment strategy of CABG (n = 914) or PTCA (n = 915) and were followed for an average of 5.4 years. Analysis of outcome events was performed according to the intention to treat.

Results. The respective in-hospital event rates for CABG and PTCA were 1.3 percent and 1.1 percent for mortality, 4.6 percent and 2.1 percent for Q-wave myocardial infarction ($P < 0.01$), and 0.8 percent and 0.2 percent for stroke. The five-year survival rate was 89.3 percent for those assigned to CABG and 86.3 percent for those assigned to PTCA ($P = 0.19$; 95 percent confidence interval of the difference in survival, -0.2 percent to 6.0 percent). The respective five-year survival rates free from Q-wave myocardial infarction were 80.4 percent and 78.7 percent. By five years after study entry, 8 percent of the patients assigned to CABG had undergone additional revascularization procedures, as compared with 54 percent of those assigned to PTCA; 69 percent of those assigned to PTCA did not subsequently undergo CABG. Among diabetic patients who were being treated with insulin or oral hypoglycemic agents at base line, a subgroup not specified by the protocol, five-year survival was 80.6 percent for the CABG group as compared with 65.5 percent for the PTCA group ($P = 0.003$).

Conclusions. As compared with CABG, an initial strategy of PTCA did not significantly compromise five-year survival in patients with multivessel disease, although subsequent revascularization was required more often with this strategy. For treated diabetics, five-year survival was significantly better after CABG than after PTCA.

Summary

Journal of the American College of Cardiology, 30:3:676-681

Clinical Outcome of Patients Undergoing Endoluminal Coronary Artery Reconstruction With Three or More Stents

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Objectives. We sought to evaluate the outcome of patients undergoing multiple (three or more), contiguous stent implantation within a single native coronary artery.

Background. The implantation of multiple stents within a single coronary artery is increasing in frequency, although the outcome of such patients is not well described.

Methods. Forty-five patients without previous coronary artery bypass graft surgery (CABG) undergoing multiple, contiguous stent implantation in a single coronary artery were identified. Clinical and angiographic characteristics and outcomes were analyzed.

Results. The angiographic success rate was 97.8%. The procedural success rate was 91.1%; stent occlusion during the initial hospital period occurred in four patients (8.9%). Death, myocardial infarction (MI), CABG, repeat target vessel intervention or severe angina occurred in 10 (23.3%) of 43 hospital survivors at 6-month follow-up. The indication for stent placement was threatened or abrupt closure in 30 patients (66.7%). Of the 25 patients with abrupt or threatened closure whose clinical and angiographic data would have indicated emergent CABG had stents not been available, the frequency of in-hospital death and Q wave MI was similar to that of a matched consecutive series of patients at our institution who underwent emergent CABG after failed angioplasty. At 1 year, the frequency of death, Q wave MI, CABG and severe angina at 1 year was similar in the two groups; the need for repeat percutaneous intervention was more common in the stent group (25% vs. 0%, $p = 0.01$).

Conclusions. Implantation of multiple, contiguous intracoronary stents was associated with a high initial success rate, although the incidence of early stent closure was relatively high. Adverse events at 6 months of follow-up were more frequent than previously reported for elective single-stent implantation; however, adverse angiographic characteristics such as dissection and thrombus were frequent in this group. In addition, the strategy of multiple stent implantation in the setting of failed angioplasty is a reasonable alternative to emergent CABG, although the need for further percutaneous intervention must be anticipated.

Circulation 1997 96: 3873-3879.

Long-term Angiographic and Clinical Outcome of Patients Undergoing Multivessel Coronary Stenting

Issam Moussa, Bernhard Reimers, Jeffrey Moses, Carlo Di Mario, Lucia Di Francesco, Massimo Ferraro, and Antonio Colombo

Background. Randomized clinical trials have shown that multivessel coronary angioplasty is feasible and provides similar long-term survival as bypass surgery in selected patients. However, the higher need for repeat intervention, in particular, coronary artery bypass graft surgery, remains a problem. The objective of this study was to test the hypothesis that multivessel stenting is safe and effective in reducing the need for repeat interventions, in particular, the need for bypass surgery.

Methods and Results. Between March 1993 and June 1995, 100 consecutive patients (243 lesions) had multivessel coronary stenting. High-pressure stent optimization was used in all patients. Procedural success was achieved in 97% of lesions; 2 patients (2%) required emergency bypass surgery. Angiographic follow-up was obtained in 89% of patients at 5.2 ± 2.5 months. Angiographic restenosis occurred in 22% of the lesions, but 37% of patients had 1 lesion with restenosis. Clinical follow-up was obtained in all patients at 21 ± 10 months: target lesion revascularization was needed in 30 patients (30%), repeat angioplasty in 28 patients (28%) and coronary bypass surgery in 2 patients (2%); the overall survival rate was 96% (2% noncardiac death).

Conclusions. Multivessel coronary stenting can be performed with high success rate and low need for emergency bypass surgery. Compared with historical results with multivessel percutaneous transluminal coronary angioplasty, patients who undergo multivessel stenting need less repeat interventions, in particular, less coronary bypass surgery and have similar long-term survival.

Journal of the American College of Cardiology, 30:1:180-185

Multivessel Palmaz-Schatz Stenting: Early Results and One-Year Outcome

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Objectives. To determine whether the benefits outlined in Background might extend to patients with multivessel disease, we examined the short- and long-term outcome of multivessel Palmaz-Schatz stenting.

Background. Percutaneous transluminal coronary angioplasty (PTCA) has become the dominant treatment for most patients with single-vessel coronary artery disease and has emerged as an alternative treatment for selected patients with multivessel coronary artery disease. Although multivessel angioplasty has excellent early results and low procedural complication rates, long-term outcome is tempered by the frequent need for repeat revascularization. In patients with single-vessel coronary artery disease, Palmaz-Schatz stenting has been shown to have a higher success rate and a lower restenosis rate than conventional PTCA.

Methods. A total of 103 patients (mean age 64 ± 11 years, 78 men and 25 women) underwent stenting of 212 vessels (saphenous vein graft [53%], left anterior descending coronary artery [20%], left circumflex artery [12%] and right coronary artery [15%]). In 88 patients (85%), multivessel stenting was performed during the same procedure, whereas the remaining 15 patients (15%) had staged multivessel stenting within 1 week of the index stent. Stenting involved only native coronary arteries in 33 patients and only vein grafts in 51 patients.

Results. Angiographic success was achieved in 102 patients (99%). Major complications developed in three patients: one patient died, and two patients had Q wave myocardial infarction, with no emergency coronary artery bypass graft surgery or stent thrombosis. Eleven additional patients (11%) developed non-Q wave myocardial infarction, and nine patients (9%) had local vascular complications requiring surgical repair. Clinical follow-up was available in all patients at a mean of 13 ± 8 months. At 1 year, survival was 98%, with an event-free survival rate of 80%, reflecting predominantly repeat revascularization (17% overall, with 9% target site revascularization). Multivessel native coronary stenting resulted in a higher event-free survival rate and a lower probability of repeat revascularization than did multivessel saphenous vein graft stenting.

Conclusions. In selected patients, multivessel Palmaz-Schatz stenting is technically feasible and carries both excellent early results and favorable 1-year clinical outcome.

J Am Coll of Cardiol 1998;31:1:10-19

Outcome of Coronary Bypass Surgery Versus Coronary Angioplasty in Diabetic Patients With Multivessel Coronary Artery Disease

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Objectives. This study sought to compare the outcome of percutaneous transluminal coronary angioplasty

(PTCA) (n=834) and coronary artery bypass graft surgery (CABG) (n=1805) in diabetic patients with multivessel coronary disease from an observational database.

Background. There is concern about selection of revascularization in diabetic patients with multivessel coronary artery disease.

Methods. Data were collected prospectively and entered into a computerized database. Follow-up was by letter or telephone or additional events resulting in readmission.

Results. After CABG there were more in-hospital deaths (0.36% vs. 4.99%, $p<0.0001$) and a trend toward more Q wave myocardial infarctions than after PTCA. Five- and 10-year survival rates were 78% and 45% after PTCA and 76% and 48% after CABG, respectively ($p=0.47$). At 5 and 10 years, insulin-requiring patients had lower survival rates of 72% and 31% after PTCA and 70% and 48% after CABG, respectively ($p=0.54$). Multivariate correlates of long-term mortality were older age, low left ventricular ejection fraction, heart failure and hypertension. In the total group, insulin requirement was a correlate of long-term mortality. For the total group, choice of therapy had a multivariate hazard ratio close to 1. In the insulin-requiring subgroup, the multivariate hazard ratio was 1.35 (95% confidence interval 1.01 to 1.79) for PTCA versus CABG. Corrected for baseline differences, 5- and 10-year survival rates were 68% and 36% after PTCA and 75% and 47% after CABG, respectively, in the insulin-requiring subgroup. Nonfatal events were more common after PTCA, especially additional revascularization.

Conclusions. This study reveals a high incidence of events in diabetic patients and raised further questions about angioplasty in insulin-requiring diabetic patients with multivessel disease.

Figure. Multivariate correlates of long-survival term for all diabetic patients and for insulin-requiring patients.

Am Heart J 1999 Dec;138(6 Pt 1):1105-10

Clinical outcome after multivessel coronary stent implantation.

Mathew V, Garratt KN, Holmes DR Jr

BACKGROUND: Percutaneous transluminal coronary angioplasty (PTCA) has been shown to be an effective therapy for multivessel coronary artery disease, although more frequent acute complications and an increased need to repeat revascularization than with single-vessel PTCA continue to be limitations. Intracoronary stent placement has been shown to reduce the rate of acute complications and the need for subsequent revascularization. We sought to evaluate the outcome among patients undergoing successful multivessel

coronary intervention with stents. **METHODS:** The participants were 175 patients without coronary artery bypass grafts who underwent multivessel coronary revascularization in which stent placement was attempted in all treated segments from January 1992 through March 1998 at our institution. Clinical and angiographic characteristics and outcomes were analyzed. **RESULTS:** Stent placement was attempted for 428 coronary lesions. The angiographic success rate was 100%. Modified American College of Cardiology-American Heart Association type B2 and C lesions accounted for 74.5% of the lesions. Three patients (1.7%) died in the hospital. No patient had Q-wave myocardial infarction or needed coronary artery bypass grafting. Procedural success was achieved for 172 patients (98.3%). The Kaplan-Meier probability of freedom from death or myocardial infarction at 12 months was 96.6%, of any revascularization was 81.7%, and of death, myocardial infarction, and any revascularization combined was 79.8%. The use of long-acting nitrates at 12 months was reduced (34.3% versus 19.1%, $P = .01$). **CONCLUSIONS:** Multivessel coronary stent placement is associated with an excellent procedural success rate despite a high rate of adverse lesion characteristics and a high event-free survival rate during the follow-up period. The likelihood that revascularization will not have to be repeated during the first follow-up year is significantly better than that for historic controls of multivessel PTCA.

Summary

1. Angiographic success rate: 100%.
2. In hospital death: three patients (1.7%), no Q-wave MI, no emergency CABG
3. Kaplan-Meier probability of freedom from death or myocardial infarction at 12 months; 96.6%, any revascularization; 81.7%, death, myocardial infarction, and any revascularization combined; 79.8%.

Catheter Cardiovasc Interv 1999 Dec;48(4):343-9

One-year outcome in multivessel coronary disease patients undergoing coronary stenting.

De Servi S, Mariani G, Bossi I, Klersy C, Rubartelli P, Niccoli L, Repetto A, Giommi L, Baduini G, Maresta A, Repetto S

The purpose of this study was to assess 1-year clinical outcome of patients with multivessel coronary artery disease (CAD) who underwent coronary stenting and were prospectively enrolled in the Registro Impianto Stent Endocoronarico (RISE). Of 939 consecutive patients included in the registry, 377 patients with angiographic evidence of multivessel CAD had a 1-year clinical follow-up. All patients underwent PTCA and

single or multiple stenting in at least one vessel. Angiographic optimization was usually performed by using high-pressure balloon dilation. After the procedure, continuation of aspirin (at least 250 mg/day) was recommended, whereas the use of anticoagulation or ticlopidine was determined by the physician in charge of the patient in the various centers. Major adverse cardiac events were defined as death, Q-wave or non-Q-wave myocardial infarction and target vessel revascularization. Mean age of patients (311 men, 66 women) was 60 +/- 10 years. Globally, there were 596 stents implanted (72% Palmaz-Schatz stents) in 434 vessels. In about 75% of the procedures, an inflation pressure > 12 atm was used. Angiographic success rate was 98.5%. After stenting, 77% of patients received antiplatelet treatment with ticlopidine and aspirin. During hospitalization, there were 34 major adverse cardiac events in 24 patients. At 1-year follow-up, 309 patients were alive and event-free; cumulative incidence of death, myocardial infarction, and repeat revascularization were 2.9%, 4.7%, and 10.8%, respectively. By Cox regression analysis, multiple stents implantation (HR 1.72, 95% CI 1-2.97), left anterior descending artery revascularization (HR 1.86, 95% CI 1.01-3.42), use of inflation pressure > 12 atm (HR 0.93, 95% CI 0.89-0.97), ticlopidine therapy (HR 0.41, 95% CI 0.23-0.74), and stent length (HR 1.03, 95% CI 1.01-1.05) were associated with 1-year major cardiac events. In patients with multivessel CAD undergoing stent implantation in at least one vessel, 1-year follow-up is favorable and the need for repeat revascularization procedures, based on clinical data, is lower than previously reported for conventional PTCA.

Summary

1. Angiographic success: 98.5%.
2. In-hospital MACE: 24 patients
3. 1-year follow-up: cumulative incidence of death - 2.9%, myocardial infarction - 4.7%, and repeat revascularization 10.8%
4. Predictors for 1-year MACE: multiple stents implantation (HR 1.72, 95% CI 1-2.97), left anterior descending artery revascularization (HR 1.86, 95% CI 1.01-3.42), use of inflation pressure > 12 atm (HR 0.93, 95% CI 0.89-0.97), ticlopidine therapy (HR 0.41, 95% CI 0.23-0.74), and stent length (HR 1.03, 95% CI 1.01-1.05)

Am J Cardiol 1999 Jul 15;84(2):147-51

Results (>6 months) of stenting of >1 major coronary artery in multivessel coronary artery disease.

Hernandez-Antolin RA, Alfonso F, Goicolea J, Perez-Vizcayno MJ, Banuelos C, Fernandez-Ortiz A, Escaned J, Azcona L, Rodriguez A, Fernandez C, Macaya C

Multivessel percutaneous transluminal coronary angioplasty (PTCA) is associated with a high requirement for further revascularization procedures. Although stenting can reduce restenosis and clinical events after 1-vessel intervention, little information is available after multivessel coronary stenting. We followed up 136 patients (9% of 1,481 undergoing stenting in our center) who had had stent implantation in at least 2 different major native coronary arteries and were followed-up for >6 months. Each patient had received a mean of 2.3 +/- 0.6 stents (1.13 +/- 0.4 stents per lesion) and procedural success was 95%. In-hospital complications included 1 death, 1 Q-wave infarction, 5 non-Q-wave myocardial infarctions, and 1 repeat PTCA. After a mean of 18 +/- 13 months, 7 patients died (3 of heart failure, 4 of noncardiac causes), 2 required coronary bypass surgery, 1 had a myocardial infarction, 13 target vessel repeat PTCA, and 4 non-target vessel PTCA. Survival free of major cardiac events was 75% at 3 years. A history of heart failure, dilation of a restenotic lesion, and 3-vessel dilation were independent negative predictors of event-free survival. Angiographic follow-up was available in 86 patients: 56 (65%) were restenosis free, 23 (27%) had 1-vessel restenosis, and 6 (7%) had 2-vessel and 1 patient 3-vessel restenosis. Restenosis per vessel was 23% (41 of 177). Reference diameter, past-PTCA minimal luminal diameter, and length of the stent were independent predictors of restenosis. We conclude that multivessel stenting provides good midterm results in selected patients with multivessel coronary artery disease. Midterm events are less frequent than previously reported after balloon PTCA.

Summary

1. Procedural success: 95%.
2. In-hospital complications: 1 death, 1 Q-wave MI, 5 non-Q MI, and 1 repeat PTCA.
3. After a mean of 18 +/- 13 months: 7 death, 2 CABG, 1 MI, 13 target vessel repeat PTCA
4. Survival free of major cardiac events: 75% at 3 years.
5. Negative predictors of event-free survival: history of heart failure, dilation of a restenotic lesion, and 3-vessel dilation
6. Predictors of restenosis: reference diameter, past-PTCA MLD, and length of the stent

J Am Coll Cardiol 1999 Feb;33(2):420-6

Procedural results and late clinical outcomes following multivessel coronary stenting.

Kornowski R, Mehran R, Satler LF, Pichard AD, Kent KM, Greenberg A, Mintz GS, Hong MK, Leon MB

OBJECTIVES: To evaluate in-hospital and long-term clinical outcomes in a large consecutive series of patients undergoing percutaneous multivessel stent intervention. **BACKGROUND:** High restenosis and recurrent angina rates have limited the clinical outcomes of multivessel coronary angioplasty before stents were available to improve angioplasty results. **METHODS:** We evaluated in-hospital and long-term clinical outcomes (death, Q-wave myocardial infarction [MI], and repeat revascularization rates at one year) in 398 consecutive patients treated with coronary stents in two (94% of patients) or three native arteries, compared to 1,941 patients undergoing stenting procedure in a single coronary artery between January 1, 1994 and August 29, 1997. **RESULTS:** Overall procedural success was obtained in 96% of patients with two- or three-vessel stenting and in 97% of patients with single-vessel stent intervention ($p = 0.36$). Procedural complications were also similar (3.8% for multivessel versus 2.9% for single vessel, $p = 0.14$). During follow up, target lesion revascularization was 15% in multivessel and 16% in single-vessel interventions ($p = 0.38$), and repeat revascularization (calculated per treated patient) was also similar for both groups (20% vs. 21%, $p = 0.73$). There was no difference in death (1.4% vs. 0.7%, $p = 0.26$), and Q-wave MI (1.2% vs. 0%, $p = 0.02$) was lower following multivessel interventions. Overall cardiac event-free survival was similar for both groups ($p = 0.52$). **CONCLUSIONS:** Unlike previous conventional angioplasty experiences, multivessel stenting has (1) similar in-hospital procedural success and major complication rates and (2) similar long-term (one year) clinical outcomes compared with single-vessel stenting. Thus, stents may be a viable therapeutic strategy in carefully selected patients with multivessel coronary disease.

Summary

American Heart Journal. 139(4):638-42, 2000

Multivessel coronary stenting versus bypass surgery in patients with multivessel coronary artery disease and normal left ventricular function: immediate and 2-year long-term follow-up.

Kim SW. Hong MK. Lee CW. Kim JJ. Park SW. Park SJ.

BACKGROUND: Compared with coronary artery bypass surgery (CABG), the clinical benefits of intracoronary stenting have not been established in patients with multivessel coronary lesions. **METHODS AND RESULTS:** To compare the clinical outcomes of intracoronary stenting with that of CABG, we reviewed the outcomes of patients with multivessel coronary artery disease from an observational database. Two hundred consecutive patients with multivessel coronary artery disease and normal left ventricular function were evaluated. In 200 patients, multivessel stenting was performed in 100 and CABG was performed in 100. Complete revascularization was achieved in 95% in the CABG group and in 69% in the stent group ($P < .05$). The duration of total hospital stay and coronary care unit admission was significantly shorter in the stent group ($P < .05$). The long-term survival was similar between the 2 groups. There were no significant differences of cardiac events between the 2 groups except for the recurrence of angina (19% in stenting vs 8% in CABG, $P = .03$) and target lesion revascularization (19% vs 2%, $P < .01$) in the patients with stents. **CONCLUSIONS:** In selected patients with multivessel coronary artery disease and normal left ventricular function, intracoronary stenting may offer an effective alternative to coronary bypass surgery.

Summary

Fig. 1. Cumulative probability of actual survival was 99% in stent group and 97% in CABG group during follow-up.

Fig. 2. Event-free (freedom from death, myocardial infarction, and target lesion revascularization) survival rate was 70% in stent group vs 86% in CABG group

Journal of the American College of Cardiology. 35(5):1116-21, 2000

Eight-year mortality in the Emory Angioplasty versus Surgery Trial (EAST)

Kosinski AS. Guyton RA. Lembo NJ. Weintraub WS.

OBJECTIVES: To evaluate the long-term outcome of patients randomized to coronary bypass surgery or coronary angioplasty. **BACKGROUND:** The Emory Angioplasty versus Surgery Trial (EAST) is a single center randomized comparison of a strategy of initial coronary angioplasty (n = 198) or coronary bypass surgery (n = 194) for patients with multivessel coronary artery disease. The primary end point (death, myocardial infarction or a large ischemic defect at 3 years) was not different, and repeat revascularization was significantly greater in the angioplasty group. Subsequently, the National Heart, Lung and Blood Institute supported a five-year extension of the trial. **METHODS:** After the three year anniversary visit, annual questionnaires, telephone contact and examination of medical records were accomplished until death or the eight year anniversary in 100% of the patients surviving at 3 years. **RESULTS:** Survival at 8 years is 79.3% in the angioplasty group and 82.7% in the surgical group (p = 0.40). Patients with proximal left anterior descending stenosis and those with diabetes tended to have better late survival with surgical intervention although not reaching statistical significance. After the first 3 years, repeat interventions remained relatively equal for both treatment groups. **CONCLUSIONS:** Long-term survival is not significantly different between angioplasty and surgery, and late (three to eight year) revascularization procedures were infrequent. Patients without treated diabetes had similar survival in both groups.

Summary

Journal of Invasive Cardiology. 12(8):410-5, 2000

Multi-vessel coronary stenting-procedural results and late clinical outcomes: a comparison with single-vessel stenting.

Kaul U. Singh B. Sudan D. Sapra R. Kachru R. Ghose T. Dixit NS.

The purpose of this study was to assess the 1-year clinical outcome of patients with multi-vessel coronary artery disease (CAD) who underwent coronary stenting, and to compare the results with single-vessel coronary stenting carried out during the same period. We evaluated the in-hospital and 12-month clinical outcomes [death, Q-wave myocardial infarction (MI) and repeat revascularization rates at one year] in 384 consecutive patients treated with coronary stents in 2 (92% of patients) or 3 of the native coronary arteries and compared

the outcome to 624 consecutive patients undergoing stenting in a single coronary artery between January 1, 1997 and January 31, 1999. The overall procedural success was obtained in 99% of patients with 2- or 3-vessel stenting and 98% of patients with single-vessel stenting. Procedural complications were similar (2.9% vs 2.6%; $p = 0.12$). During follow-up, target lesion revascularization was 16% in multi-vessel and 14% in single-vessel stenting ($p = 0.38$) and repeat revascularization was also similar for both groups (19% vs. 20%; $p = 0.73$). There was no difference in death (0.8% vs. 1.3%; $p = 0.31$) and Q-wave MI (0.7% vs. 1.4%; $p = 0.16$) in the 2 groups. Overall cardiac event-free survival was similar for both groups (76% vs. 78%; $p = 0.54$). Multi-vessel stenting in carefully selected patients in our experience had a high procedural success with very low complication rates. The one-year clinical outcomes were acceptable and were similar to the results of single-vessel stenting.

Summary

Catheterization & Cardiovascular Interventions. 49(1):19-22, 2000

Contemporary trends in coronary intervention: a report from the Registry of the Society for Cardiac Angiography and Interventions.

Laskey WK. Kimmel S. Krone RJ

This report of the Registry for the Society for Cardiac Angiography and Interventions provides data on the trends in coronary interventional procedures from the time period June 1966 through December 1998. A total of 19,510 consecutive coronary interventional procedures were recorded. Over this time period, significant trends in coronary stent implantation were recorded along with a decreasing reliance on balloon angioplasty as sole therapy. Patients with acute myocardial infarction comprised an increased fraction of all procedures. Almost half of all interventions were performed in patients with multivessel disease. Finally, decreasing rates of in-hospital death and emergent bypass surgery compared to prior reports from the registry characterize the current practice of interventional cardiology

American Heart Journal. 140(4):556-564, 2000.

Projected long-term costs of coronary stenting in multivessel coronary disease based on the experience of the Bypass Angioplasty Revascularization Investigation (BARI).

Yock, Cynthia A. MS; Boothroyd, Derek B. MS; Owens, Douglas K. MD, MS; Winston, Carla MA; Hlatky, Mark A. MD

Background: Stents are now used in the majority of percutaneous coronary revascularization procedures. It is not clear whether the higher initial cost of stenting is later repaid by reducing costly complications and repeat revascularization procedures, especially for patients with multivessel disease. **Methods:** To project the long-term costs of using coronary stents, angioplasty, or bypass surgery to treat patients with multivessel coronary artery disease, we developed a decision model based on the outcomes documented in the Bypass Angioplasty Revascularization Investigation (BARI) randomized trial of coronary artery bypass grafting (CABG) and percutaneous transluminal coronary angioplasty (PTCA). We studied 2 clinical strategies: provisional stenting of suboptimal PTCA results and primary stenting of all angiographically eligible lesions. The cost of CABG was also updated to reflect contemporary practice. **Results:** Provisional stenting had lower projected costs over a 4-year period than either traditional PTCA (-\$1742, or -3.4%) or contemporary CABG (-\$832, or -1.7%), mostly because of reductions in emergency CABG after PTCA. In contrast, primary stenting had higher projected costs over a 4-year period than either PTCA (+\$333, or +0.7%) or contemporary CABG (+\$1243, or +2.5%), mainly because of the higher initial procedure costs. These results were not substantially altered when we systematically varied the key parameters of the models in 1-way and 2-way sensitivity analyses.

Conclusions: A primary stenting strategy in patients with multivessel disease has higher projected long-term costs than CABG. In contrast, a provisional stenting strategy in multivessel disease has lower projected costs than either PTCA or CABG.

Summary

Fig. 3. Change in 4-year cost of PTCA (vertical axis) from stenting under provisional stent strategy (open bars) or primary stent strategy (solid bars). First set of bars shows change in initial procedure costs from stenting. Next 3 sets of bars indicate cost savings as a result of reducing staged procedures, reducing immediate PTCA complications, and reducing repeat revascularization procedures. Final set of bars indicates total effect of all factors on 4-year cost.

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