Multivessel disease and CTO - an indication for CABG
The role of surgery in CTO and MV disease

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NEW FRONTIERS
IN CARDIOLOGY
Focus on CTO

EUROPEAN SOCIETY OF CARDIOLOGY®

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2018 ESC/EACTS Guidelines on myocardial revascularization

The Task Force on myocardial revascularization of the European Society of Cardiology (ESC) and European Association for Cardio-Thoracic Surgery (EACTS)

Developed with the special contribution of the European Association for Percutaneous Cardiovascular Interventions (EAPCI)

"Broadly speaking, the treatment of CTOs may be considered analogous to the treatment of non-CTO lesions"

Recommendations according to extent of CAD	CABG		PCI	
	Class[a]	Level[b]	Class[a]	Level[b]
One-vessel CAD				
Without proximal LAD stenosis.	IIb	C	I	C
With proximal LAD stenosis [68, 101, 139–144].	I	A	I	A
Two-vessel CAD				
Without proximal LAD stenosis.	IIb	C	I	C
With proximal LAD stenosis [68, 70, 73].	I	B	I	C
Left main CAD				
Left main disease with low SYNTAX score (0–22) [69, 121, 122, 124, 145–148].	I	A	I	A
Left main disease with intermediate SYNTAX score (23–32) [69, 121, 122, 124, 145–148].	I	A	IIa	A
Left main disease with high SYNTAX score (≥33) [69, 121, 122, 124, 146–148].[c]	I	A	III	B
Three-vessel CAD without diabetes mellitus				
Three-vessel disease with low SYNTAX score (0–22) [102, 105, 121, 123, 124, 135, 149].	I	A	I	A
Three-vessel disease with intermediate or high SYNTAX score (>22) [102, 105, 121, 123, 124, 135, 149].[c]	I	A	III	A
Three-vessel CAD with diabetes mellitus				
Three-vessel disease with low SYNTAX score 0–22 [102, 105, 121, 123, 124, 135, 150–157].	I	A	IIb	A
Three-vessel disease with intermediate or high SYNTAX score (>22) [102, 105, 121, 123, 124, 135, 150–157].[c]	I	A	III	A

COMPLETE VS. INCOMPLETE REVASCULARIZATION IN MVD

Accepted Manuscript

Outcomes after Complete versus Incomplete Revascularization of Patients with Multivessel Coronary Artery Disease: A Meta-Analysis of 89,883 Patients Enrolled in Randomized Clinical Trials and Observational Studies

Santiago Garcia, MD Yader Sandoval, MD Henri Roukoz, MD, MS Selcuk Adabag, MD, MS Mariana Canoniero, MD Demetris Yannopoulos, MD Emmanouil S. Brilakis, MD, PhD

PII: S0735-1097(13)02176-1

DOI: 10.1016/j.jacc.2013.05.033

- Mortality benefit associated with CR was consistent across studies irrespective of revascularization modality and definition of CR.

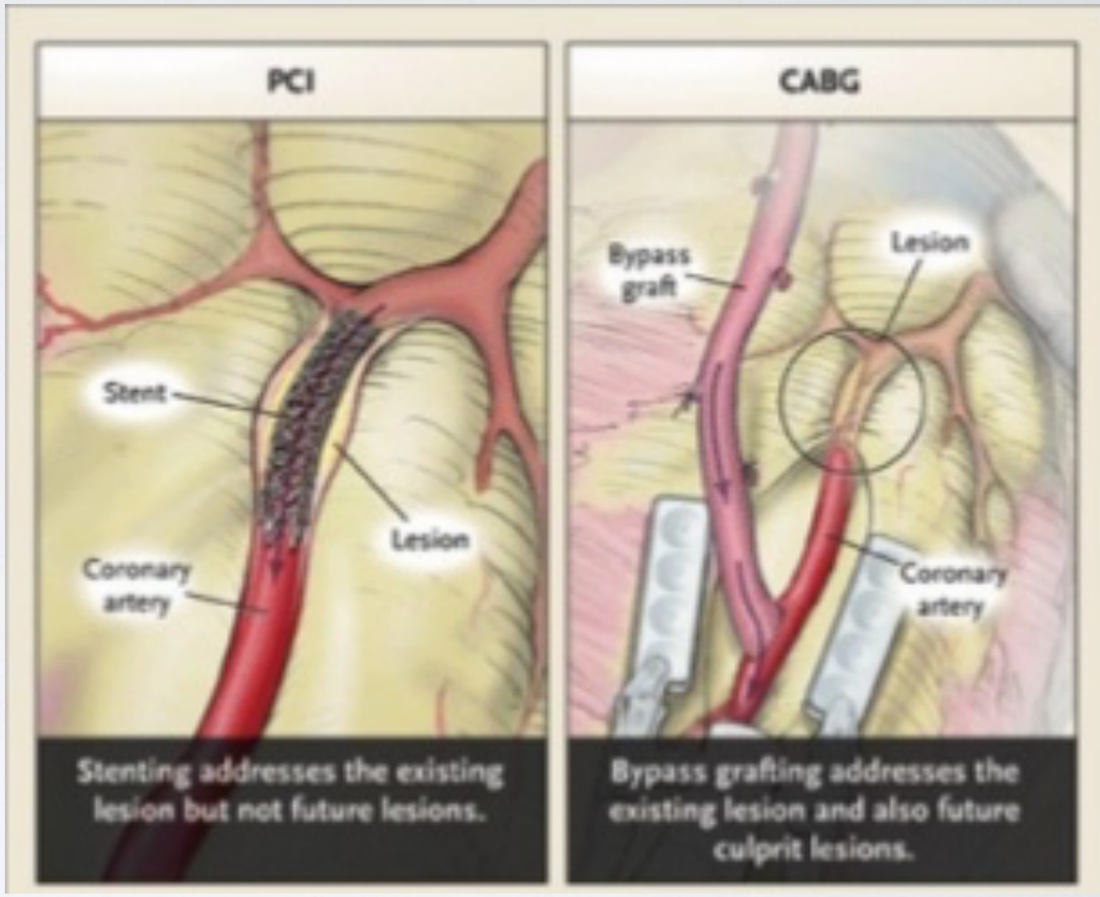
- CR is achieved more commonly with CABG than PCI. Among patients with MVD CAD, CR may be the optimal revascularization strategy.

PREVENTIVE EFFECT OF CABG

- CABG diminishes the impact of future lesions by providing distal flow

- Arterial grafting, specially IMA grafting, protects and dilates distal coronary vessel

- PCI treats the current lesions



SPECIFICITY OF CTO PCI

- Slightly less successful the non CTO PCI
- Complex lesion crossing techniques

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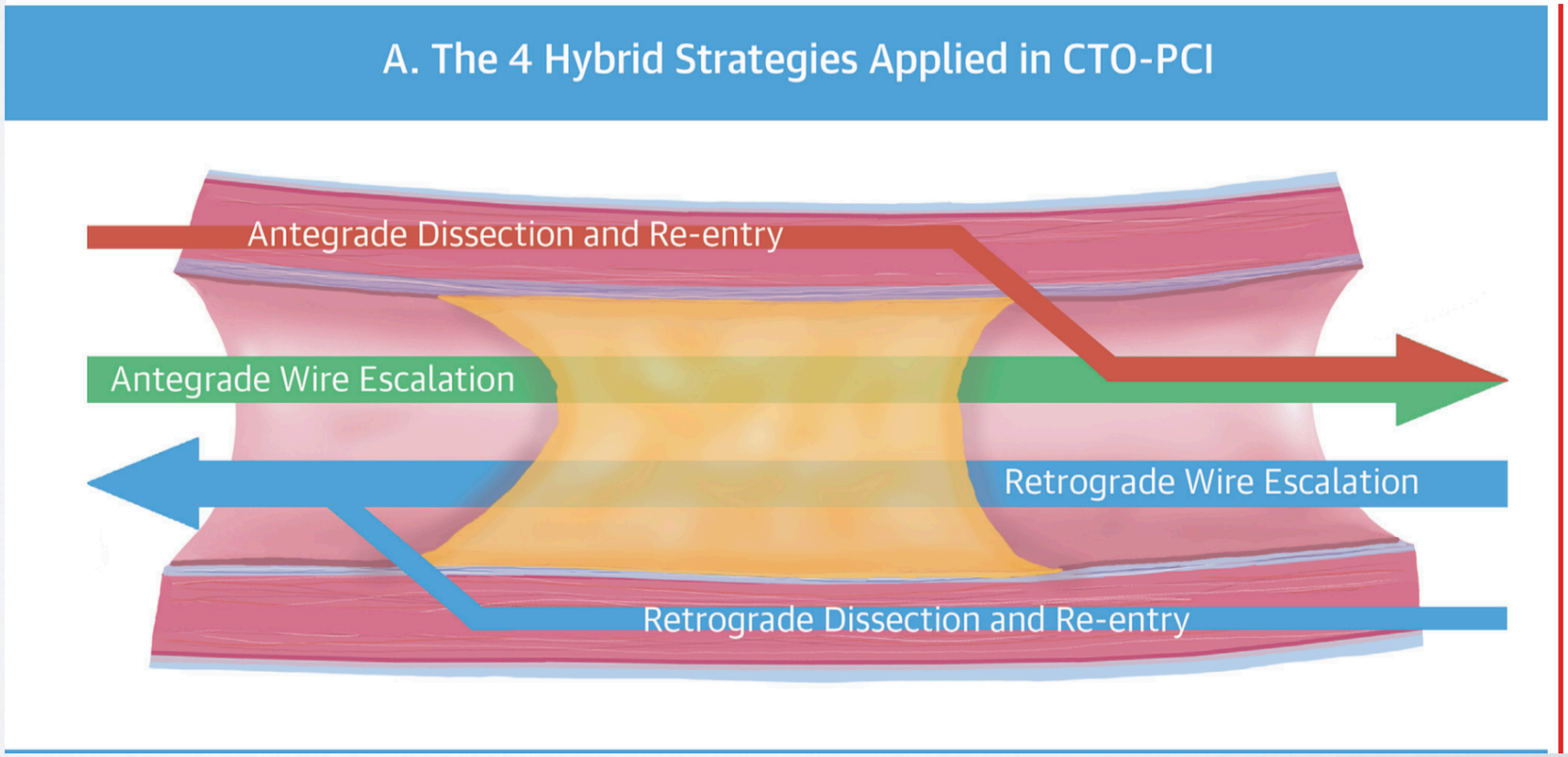
The Hybrid Algorithm for Treating Chronic Total Occlusions in Europe

The RECHARGE Registry

Joren Maeremans, MSc,[a,b] Simon Walsh, MD,[c] Paul Knaapen, MD, PhD,[d] James C. Spratt, MD,[e] Alexandre Avran, MD,[f] Colm G. Hanratty, MD,[c] Benjamin Faurie, MD, PhD,[g] Pierfrancesco Agostoni, MD,[h,i] Erwan Bressollette, MD,[j] Peter Kayaert, MD,[k] Alan J. Bagnall, MD, PhD,[l,m] Mohaned Egred, MD,[l,m] Dave Smith, MD,[n] Alexander Chase, MD, PhD,[n] Margaret B. McEntegart, MD, PhD,[o] William H.T. Smith, MB, BChir, PhD,[p] Alun Harcombe, MD,[p] Paul Kelly, MD,[q] John Irving, MD,[r] Elliot J. Smith, MD,[s] Julian W. Strange, MD,[t] Joseph Dens, MD, PhD[a,b]



WHY ARE WE TALKING ABOUT IT

- Enthusiasm for CTO PCI has increased, as evidence has demonstrated that successful CTO PCI improves the quality of life, the need for CABG, left ventricular function, and potentially even survival.

CTO PCI is feasible and safe

MODERN CTO PCI RESULTS

- 111,273 patients with obstructive coronary artery disease, **26.4% had CTO**
- Elective CTO PCI was attempted in **8.1%**, with a procedural success rate of **79.7%**

Contemporary Incidence, Management, and Long-Term Outcomes of Percutaneous Coronary Interventions for Chronic Coronary Artery Total Occlusions

Insights From the VA CART Program

Thomas T. Tsai, MD, MSc,[a,b,c] Maggie A. Stanislawski, MS,[a,b] Kendrick A. Shunk, MD, PhD,[d,e] Ehrin J. Armstrong, MD, MSc,[a,b] Gary K. Grunwald, PhD,[a,b] Alan H. Schob, MD,[f,g] Javier A. Valle, MD,[a,b] Carlos E. Alfonso, MD,[f,g] Brahmajee K. Nallamothu, MD, MPH,[h,i] P. Michael Ho, MD, PhD,[a,b] John S. Rumsfeld, MD, PhD,[a,b] Emmanouil S. Brilakis, MD, PhD[j,k]

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OVERVIEW OF CTO PCI RESULTS

- **CTO more common in RCA (42%)**, LAD (24%), and then Cx (16%)
- Success PCI LAD>RCA
- Increased use of resources, fluoroscopy and IV contrast

Contemporary Incidence, Management, and Long-Term Outcomes of Percutaneous Coronary Interventions for Chronic Coronary Artery Total Occlusions

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OVERVIEW OF CTO PCI RESULTS - COMPLICATIONS

TABLE 4 Periprocedural Complications: Failed Chronic Total Occlusion Percutaneous Coronary Intervention Versus Successful Chronic Total Occlusion Percutaneous Coronary Intervention

	Total (N = 2,394)	Failed CTO PCI (n = 486)	Successful CTO PCI (n = 1,908)	p Value
Any complications	103 (4.30%)	39 (8.02%)	64 (3.35%)	<0.0001
Dysrhythmia	7 (0.29%)	1 (0.21%)	6 (0.31%)	1.00
Acute pulmonary edema	0 (0.00%)	0 (0.00%)	0 (0.00%)	1.00
Anaphylactic shock	1 (0.04%)	1 (0.21%)	0 (0.00%)	0.20
Groin hematoma	15 (0.63%)	3 (0.62%)	12 (0.63%)	1.00
Retroperitoneal hematoma	0 (0.00%)	0 (0.00%)	0 (0.00%)	1.00
Acute cardiogenic shock	2 (0.08%)	1 (0.21%)	1 (0.05%)	0.36
Stroke	1 (0.04%)	0 (0.00%)	1 (0.05%)	1.00
Periprocedural MI	3 (0.13%)	3 (0.62%)	0 (0.00%)	0.0083
Cardiac tamponade	1 (0.04%)	0 (0.00%)	1 (0.05%)	0.20
CABG surgery	0 (0.00%)	0 (0.00%)	0 (0.00%)	1.00
Death	0 (0.00%)	0 (0.00%)	0 (0.00%)	1.00
Other complications*	75 (3.13%)	31 (6.38%)	44 (2.31%)	<0.0001
Other complications: dissection	19 (0.79%)	12 (2.5%)	7 (0.37%)	<0.001
Other complications: perforation	18 (0.75%)	13 (2.7%)	5 (0.26%)	<0.001

*Wrist hematoma, wire fractures, electrocardiographic changes, chest pain without electrocardiographic changes, closure device failure, failure to cross CTO, vasospasm, equipment failure, guide dissection, stent loss, aortic dissection, back pain, combative patient, balloon fracture, occluded side branch, and air embolus.

Abbreviations as in Table 1.

Successful CTO PCI is very safe
Unsuccessful CTO PCI is less safe but not unnacceptable

Contemporary Incidence, Management, and Long-Term Outcomes of Percutaneous Coronary Interventions for Chronic Coronary Artery Total Occlusions

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SPECIFICITY OF CTO CABG

- Off-pump surgery - risk?
- Favorable distal vascular bed
- Competitive flow from collaterals
- Non graftability of CTO vessels
- Periprocedural myocardial injury

IMAGING OF DISTAL VESSEL

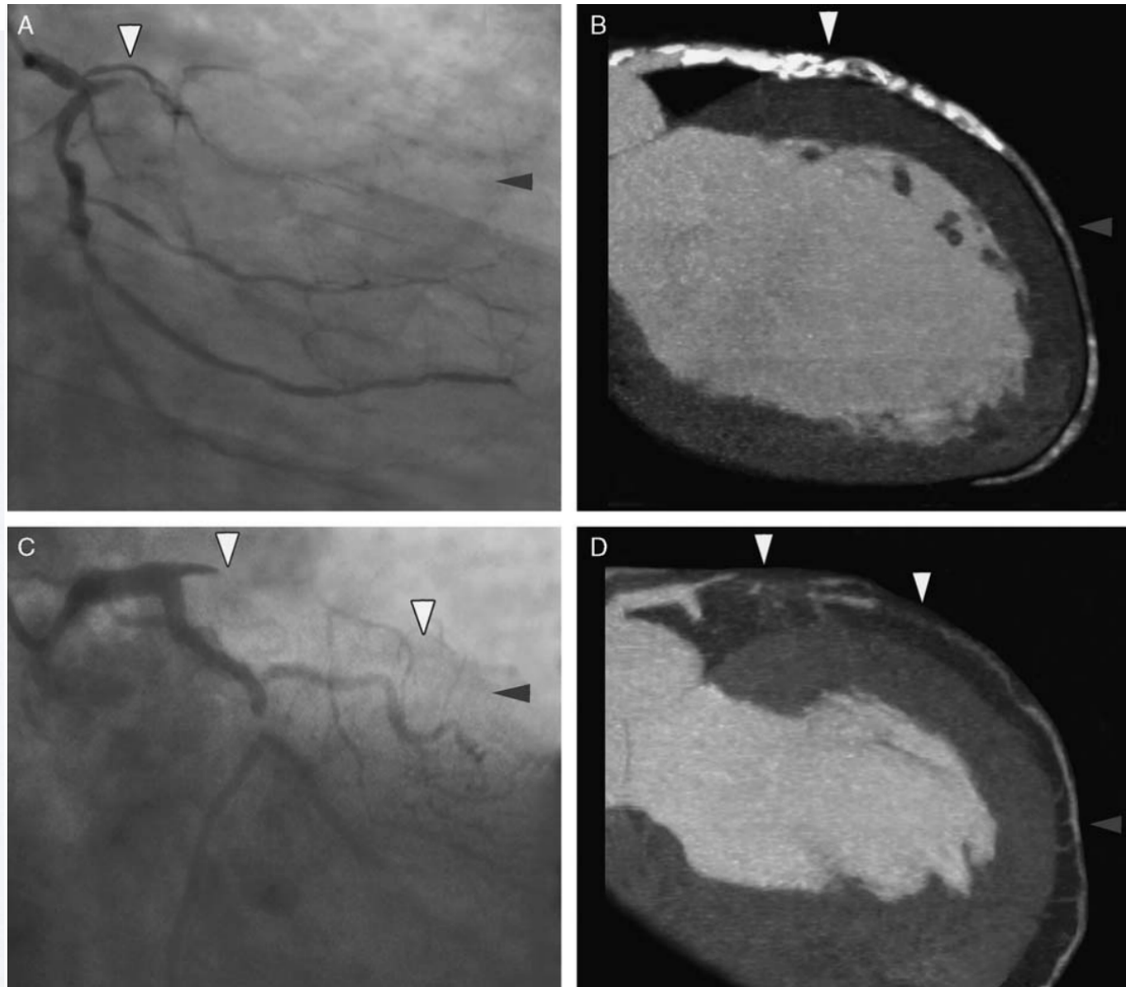
- Distal vessel may appear to be untreatable in coronary angiography

- CT scanning may be a good way to estimate probability of grafting but adds to total procedural costs and radiation

Computed Tomography to Predict Surgical Revascularization of a Left Anterior Descending Artery Occlusion Incompletely Visualized by Conventional Angiography

Cezary Kepka, MD, PhD, Maksymilian P. Opolski, MD,† Zbigniew Juraszynski, MD, PhD,‡ Mariusz Kruk, MD, PhD,* Jerzy Pregowski, MD, PhD,† Radoslaw Pracon, MD,* Wojciech Dyk, MD, PhD,‡ Marcin Demkow, MD, PhD,* Adam Witkowski, MD, PhD,† and Witold Ruzyllo, MD, PhD**

J Thorac Imaging • Volume 27, Number 3, May 2012



PERIPROCEDURAL **MI**

- Periprocedural myocardial injury is normally defined biochemically
- MACE may be a more appropriate end-point
- Conflicting results but mainly in favor of no impact on survival

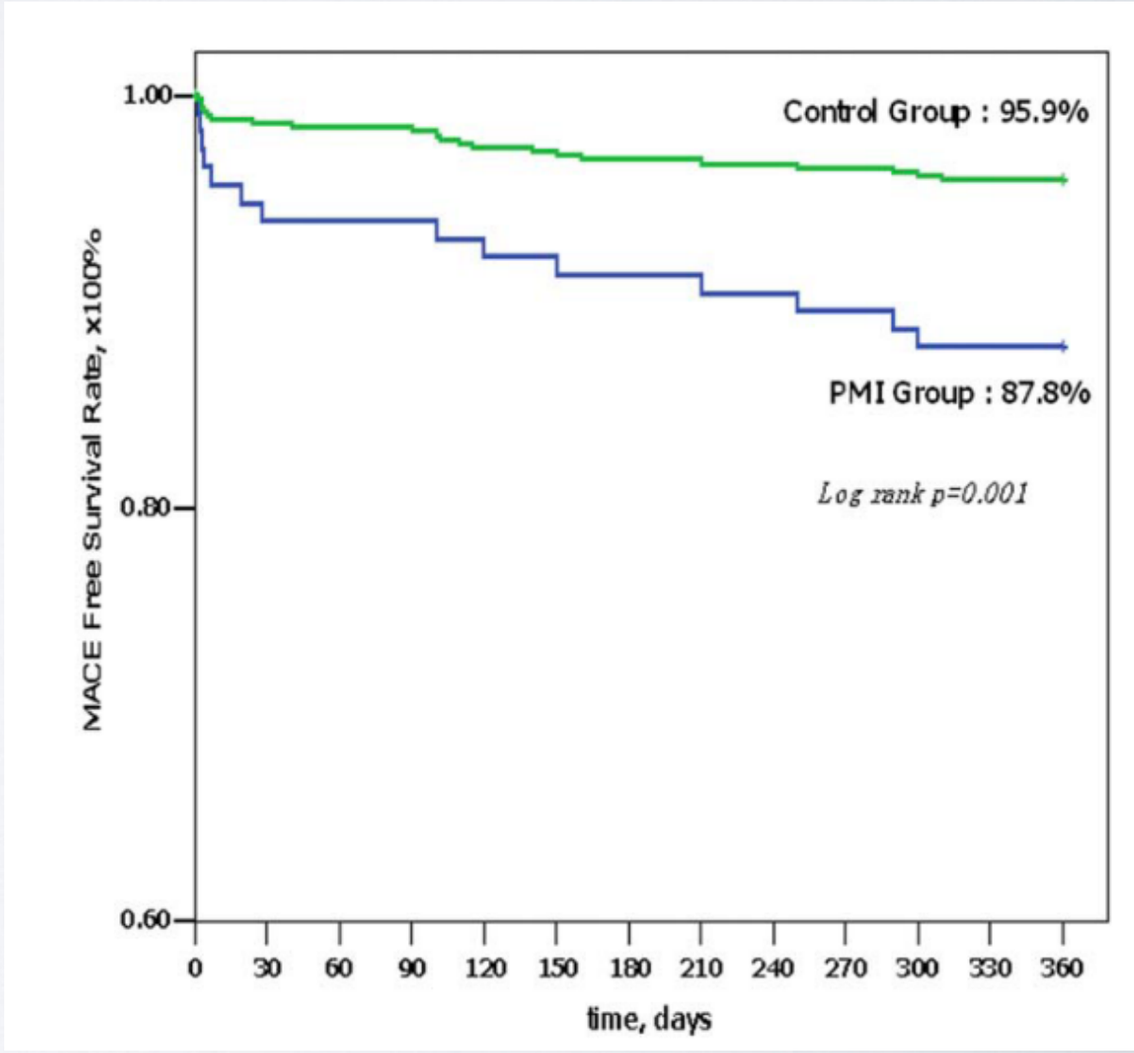
PERIPROCEDURAL **MI** - PCI

Correlates and Outcomes Related to Periprocedural Myocardial Injury during Percutaneous Coronary Intervention for Chronic Total Occlusion: Results from a Prospective, Single Center PCI Registry

Qi Zhang,[1] MD, Jian Hu,[1] MD, Zhen Kun Yang,[1] MD, Feng Hua Ding,[1] MD, Jian Sheng Zhang,[1] MD, Run Du,[1] MD, Tian Qi Zhu,[1] MD, Wei Feng Shen,[1] MD, Ajay J. Kirtane,[2] MD, and Rui Yan Zhang,[1*] MD

Catheterization and Cardiovascular Interventions 87:616–623 (2016)

- PP myocardial injury is associated with lower event-free survival
- Predictors of 1-year MACE
  - PP MI
  - MVD
  - DM
  - Female gender



PERIPROCEDURAL MI - PCI

Periprocedural Myocardial Injury in Chronic Total Occlusion Percutaneous Interventions

A Systematic Cardiac Biomarker Evaluation Study

Nathan Lo, MD,* Tesfaldet T. Michael, MD, MPH,† Danyaal Moin, MD,* Vishal G. Patel, MD,† Mohammed Alomar, MD,† Aristotelis Papayannis, MD,† Daisha Cipher, PHD,‡ Shuaib M. Abdullah, MD,† Subhash Banerjee, MD,† Emmanouil S. Brilakis, MD, PHD†

JACC: CARDIOVASCULAR INTERVENTIONS VOL. 7, NO. 1, 2014

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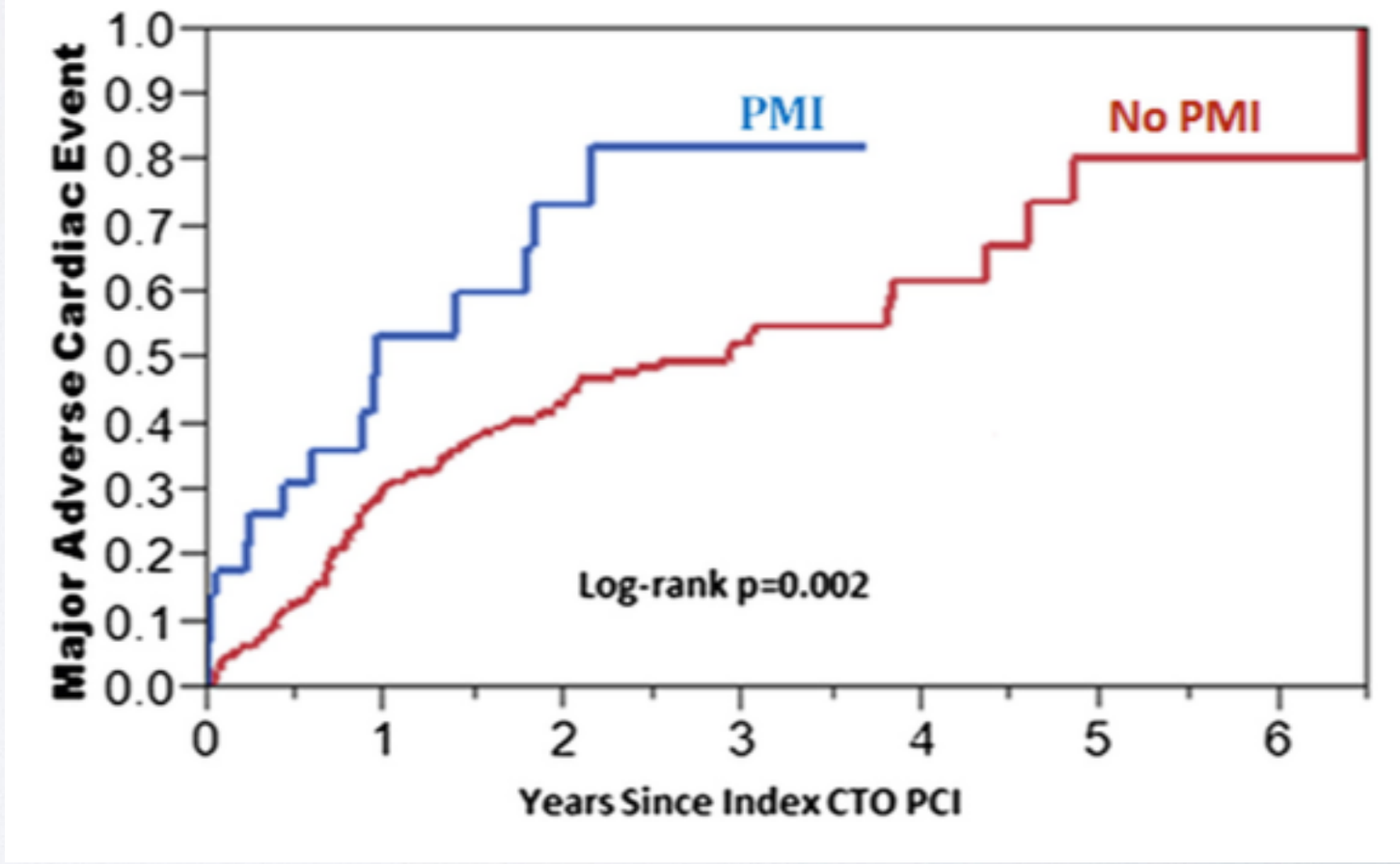
- PP myocardial injury increases MACE long term



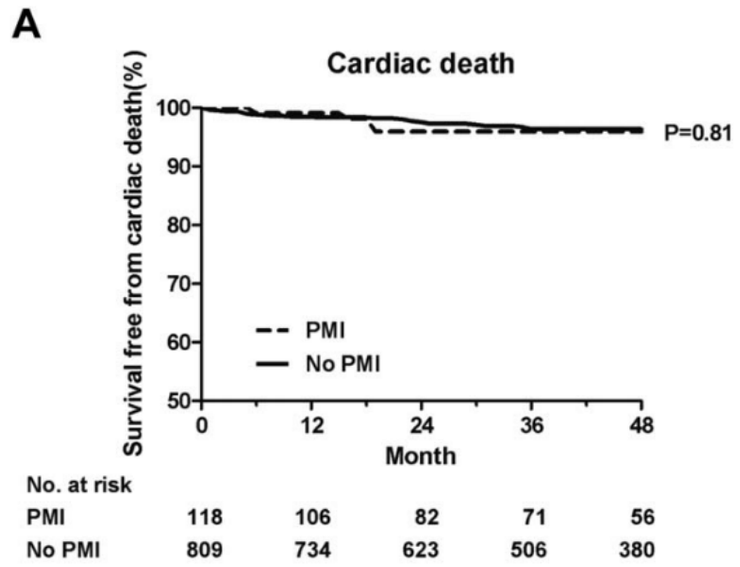
PERIPROCEDURAL **MI** - PCI VS. CABG

- F-UP 42 months
- 10,5% PCI and 16,1% CABG had PP MI
- PPMI group and no-PPMI group had **similar incidence of cardiac death**

Association of Periprocedural Myocardial Infarction With Long-Term Survival in Patients Treated With Coronary Revascularization Therapy of Chronic Total Occlusion

Woo Jin Jang,[1] MD, Jeong Hoon Yang,[2] MD, PhD, Seung-Hyuk Choi,[2*] MD, PhD, Young Bin Song,[2] MD, PhD, Joo-Yong Hahn,[2] MD, PhD, Wook Sung Kim,[2] MD, PhD, Young Tak Lee,[2] MD, PhD, Bum-Sung Kim,[3] MD, and Hyeon-Cheol Gwon,[2] MD, PhD

Catheterization and Cardiovascular Interventions 87:1042–1049 (2016)



PERIPROCEDURAL **MI** - CROSSING TECHNIQUE

Impact of Crossing Technique on the Incidence of Periprocedural Myocardial Infarction During Chronic Total Occlusion Percutaneous Coronary Intervention

Jeffrey Stetler, BS, Aris Karatasakis, MD, Georgios E. Christakopoulos, MD, Muhammad Nauman J. Tarar, MD, Suwetha Amsavelu, BS, Krishna Patel, BS, Bavana V. Rangan, BDS, MPH, Michele Roesle, RN, BSN, Erica Resendes, BS, MS, Jerrold Grodin, MD, Shuaib Abdullah, MD, Subhash Banerjee, MD, and Emmanouil S. Brilakis,* MD, PhD

- Retrograde technique
  used in more complex
  CTO´s, longer CTO´s

- Retrograde technique
  more PPMI - 33% vs. 10%
  (p=0.00011)

DOI: 10.1002/ccd.26505

Catheterization and Cardiovascular Interventions 00:00–00 (2016)

GENDER AND REVASCULARIZATION TECHNIQUE

Catheterization and Cardiovascular Interventions 87:1063–1070 (2016)

Gender Differences in the Prevalence and Treatment of Coronary Chronic Total Occlusions

Rafael Wolff,[1] MD, Paul Fefer,[1,2] MD, Merril L. Knudtson,[3] MD, Asim N. Cheema,[4,5] MD, PhD, P. Diane Galbraith,[3] BN, Msc, John D. Sparkes,[1] Msc, Graham A. Wright,[1] PhD, Harindra C. Wijeysundera,[1,5,6,7] MD, PhD, and Bradley H. Strauss,[1,5*] MD, PhD

- Women have lower prevalence of CTO´s and lower usage of CABG for treating CTO´s (smaller distal vessels?)

GENDER AND REVASCULARIZATION TECHNIQUE

Gender Differences in Long-Term Clinical Outcomes After Percutaneous Coronary Intervention of Chronic Total Occlusions

Volume 24 - Issue 10 - October 2012

Bimmer E. Claessen, MD, PhD[1,2], Alaide Chieffo, MD[3], George D. Dangas, MD, PhD[1,4], Cosmo Godino, MD[3], Seung-Whan Lee, MD[5], Kotaro Obunai, MD[1], Mauro Carlino, MD[3], Vaso Chantziara, MD[6], Irini Apostolidou, MD[6], Jos√© P.S. Henriques, MD, PhD[2], Martin B. Leon, MD[1,6], Carlo Di Mario, MD, PhD[7], Seung-Jung Park, MD[5], Gregg W. Stone, MD[1,6], Jeffrey W. Moses, MD[1,6], Antonio Colombo, MD[3], Roxana Mehran, MD[1,4], on behalf of the Multinational CTO Registry

J Invasive Cardiol. 2012 Oct;24(10):484-8

- **Men have a greater benefit** in mortality and MACE

  than women after a CTO PCI

IMPACT ON MORTALITY OF CABG PATIENTS

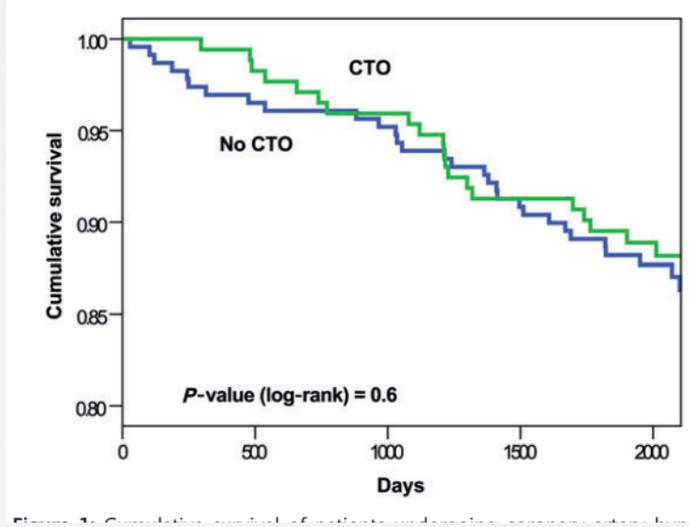
Interactive CardioVascular and Thoracic Surgery 18 (2014) 713–716
doi:10.1093/icvts/ivu038 Advance Access publication 11 March 2014

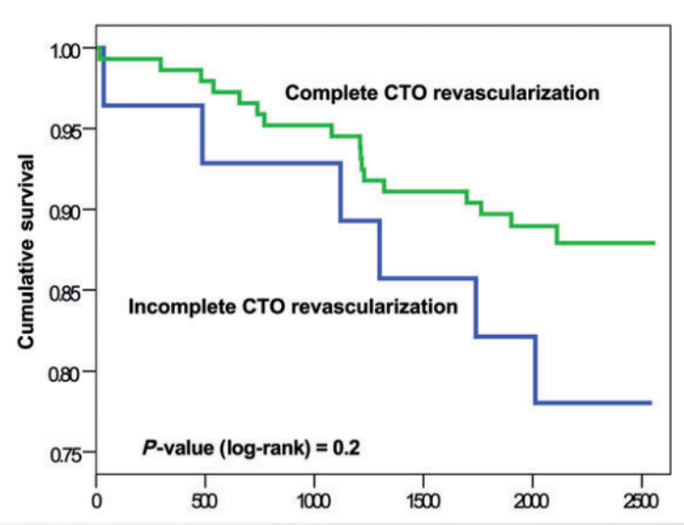
ORIGINAL ARTICLE – ADULT CARDIAC

Impact of coronary chronic total occlusions on long-term mortality in patients undergoing coronary artery bypass grafting

Paul Fefer†*, Sharon Gannot†, Ksenya Kochkina, Elad Maor, Shlomi Matetzky, Ehud Raanani, Victor Guetta and Amit Segev

- CTOs have no impact on long term mortality after CABG (all LAD´s bypassed)





- Incomplete CTO revascularization does not affect survival! [or does it?]

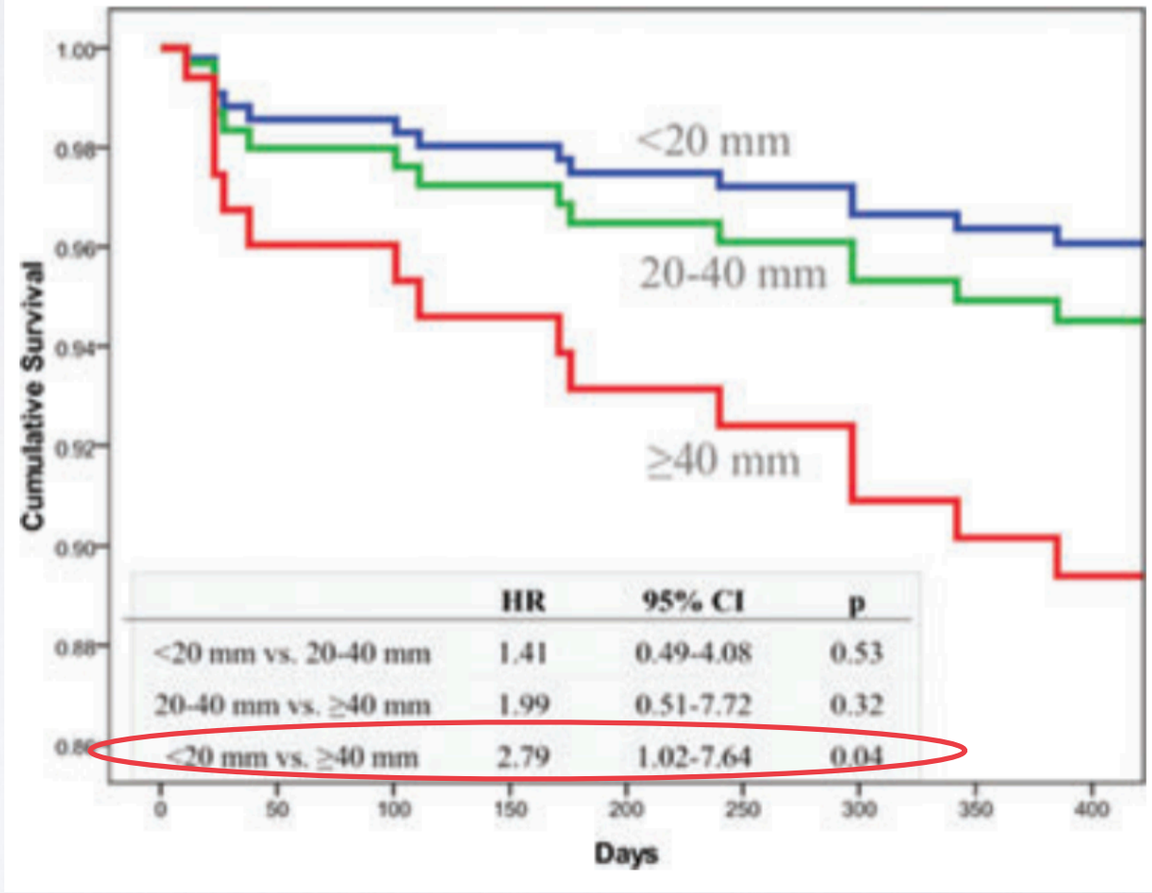
→ Not grafting a CTO vessel is difficult for a surgeon!

IMPACT ON MORTALITY OF CABG PATIENTS

- Very long CTO's (>40mm) compromise survival after CABG

Influence of Chronic Total Occlusions on Coronary Artery Bypass Graft Surgical Outcomes

Subhash Banerjee, M.D.,*† Ryan G Master, M.D.,† Matthias Peltz, M.D.,† Bernice Willis, R.N.,* Atif Mohammed, M.D.,† Bertis B. Little, Ph.D.,* Michael J. DiMaio, M.D.,† Michael E. Jessen, M.D.,† and Emmanouil S. Brilakis, M.D., Ph.D.*†



	HR	95% CI	p
<20 mm vs. 20-40 mm	1.41	0.49-4.08	0.53
20-40 mm vs. ≥40 mm	1.99	0.51-7.72	0.32
<20 mm vs. ≥40 mm	2.79	1.02-7.64	0.04

doi: 10.1111/jocs.12021 (J Card Surg 2012;27:662-667)

COLLATERAL FLOW AND CABG

Interactive CardioVascular and Thoracic Surgery 17 (2013) 944–949
doi:10.1093/icvts/ivt337 Advance Access publication 19 August 2013

ORIGINAL ARTICLE – ADULT CARDIAC

Does rich coronary collateral circulation distal to chronically occluded left anterior descending artery compete with graft flow?

Daisuke Kaku, Atsushi Nakahira*, Hidekazu Hirai, Yasuyuki Sasaki, Mitsuharu Hosono, Yasuyuki Bito, Yasuo Suehiro and Shigefumi Suehiro

- In the immediate post-op phase collateral flow may diminish graft forward flow

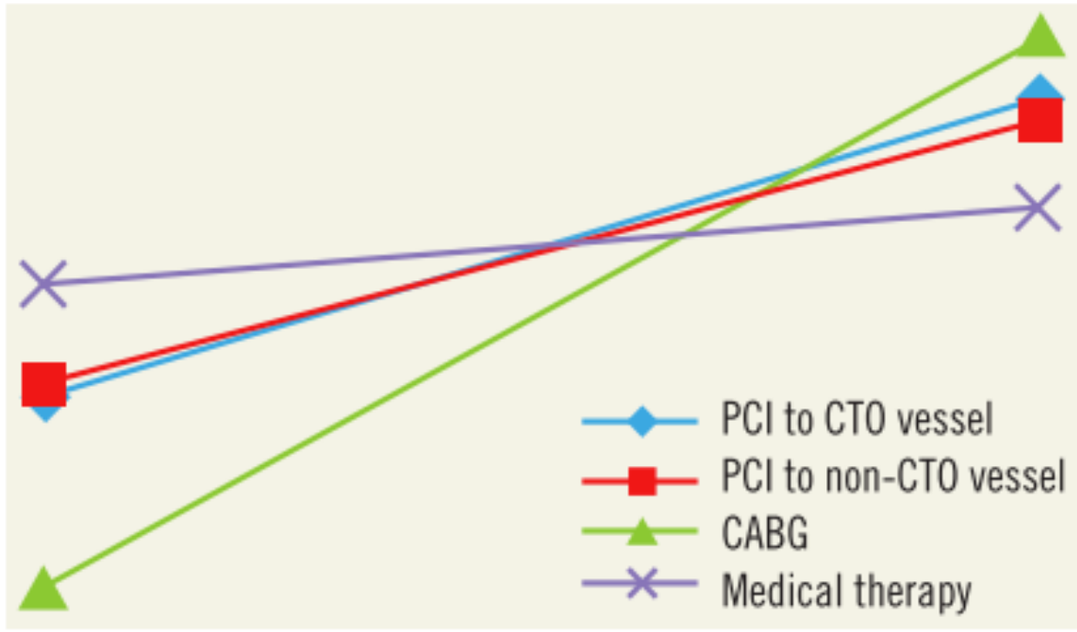
- At 5 years F-UP no MACE or death increase in patients with collateral flow

QOL IMPROVEMENT AFTER MVD REVASCULARIZATION

Relationship between initial treatment strategy and quality of life in patients with coronary chronic total occlusions

Harindra C. Wijeysundera[1,2,3,4]*, MD, PhD; Colleen Norris[5,6], PhD; Paul Fefer[1,7], MD;
P. Diane Galbraith[8], BN, MSc; Merril L. Knudtson[8], MD; Rafael Wolff[1], MD; Graham A. Wright[1], PhD;
Bradley H. Strauss[1,2], MD, PhD; Dennis T. Ko[1,2,3,4], MD, MSc

- 387 patients, multicenter, prospective
- > 90% MVD, at least one CTO
- Slightly better QOL improvement with CABG vs. PCI, but both far better than OMT



	Baseline	1 year	*p*-value for change over time	*p*-value compared to medical therapy
PCI to CTO vessel	0.833 (0.766-0.899)	0.907 (0.845-0.968)	0.02	0.11
PCI to non-CTO vessel	0.837 (0.786-0.887)	0.902 (0.852-0.953)	0.006	0.12
CABG	0.787 (0.743-0.831)	0.921 (0.874-0.967)	<0.001	<0.001
Medical therapy	0.861 (0.818-0.903)	0.880 (0.840-0.921)	0.26	NA

Figure 1. *Changes in EQ-5D.*

EuroIntervention 2014;9:1165-1172

OMT.VS. PCI.VS. CABG IN MVD CTO

Clinical outcomes of multiple chronic total occlusions in coronary arteries according to three therapeutic strategies: Bypass surgery, percutaneous intervention and medication

Bum Sung Kim [a,b,1], Jeong Hoon Yang [a,1], Woo Jin Jang [a,c], Young Bin Song [a], Joo-Yong Hahn [a], Jin-Ho Choi [a], Wook Sung Kim [d], Young Tak Lee [d], Hyeon-Cheol Gwon [a], Sang Hoon Lee [a], Seung-Hyuk Choi [a,*]

International Journal of Cardiology 197 (2015) 2–7

- Retrospective single center, 393 patients with >1 CTO
- 2003-2012

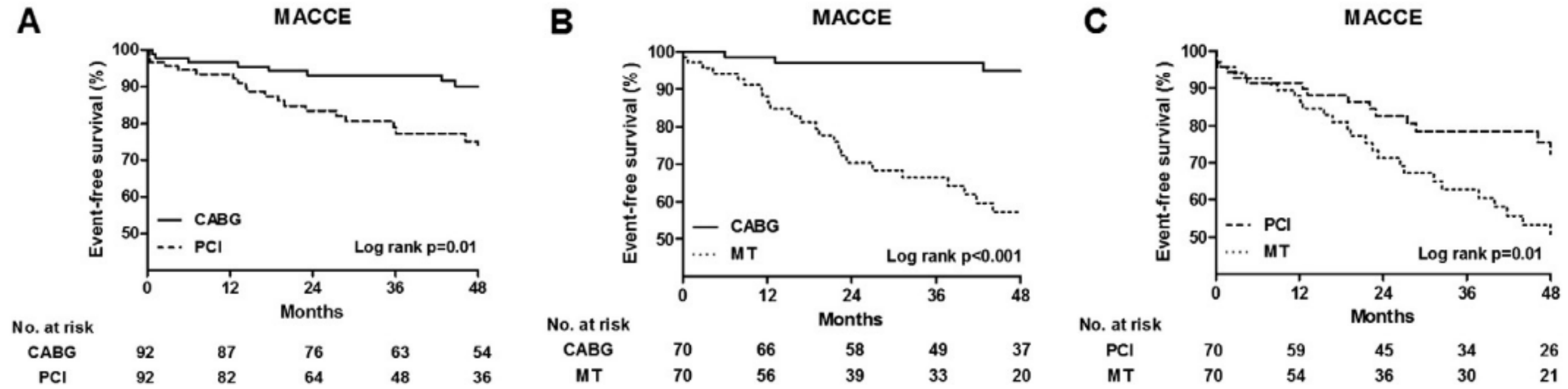
Baseline and angiographic characteristics in pre-matching populations of each group.

	CABG (n = 169)	PCI (n = 130)	MT (n = 94)	Overall *P*-value*
Age (years)	61.1 ± 9.6	62.0 ± 11.1	67.6 ± 12.6	<0.01
Male	147 (87.0)	113 (86.9)	75 (79.8)	0.22
Hypertension	105 (62.1)	84 (64.6)	61 (64.9)	0.87
Diabetes	101 (59.8)	57 (43.8)	55 (58.5)	0.02
Presentation of ACS	41 (24.3)	34 (26.2)	13 (13.8)	0.05
Renal insufficiency	6 (3.6)	20 (15.4)	9 (9.6)	<0.01
Dyslipidemia	56 (33.1)	41 (31.5)	21 (22.3)	0.17
Prior myocardial infarction	46 (27.2)	34 (26.2)	41 (43.6)	<0.01
Prior coronary intervention	28 (16.6)	29 (22.3)	26 (27.7)	0.10
Cerebrovascular disease	15 (8.9)	12 (9.2)	13 (13.8)	0.40
Current smoking	63 (37.3)	50 (38.5)	33 (35.1)	0.88
LVEF < 40%	52 (30.8)	22 (16.9)	30 (31.9)	0.01
Logistic EuroSCORE	4.3 (2.6–8.2)	4.4 (2.6–8.5)	5.2 (2.7–10.7)	0.11
CTO lesion				
LAD	99 (58.6)	72 (55.4)	52 (55.3)	0.81
LCX	126 (74.6)	97 (74.6)	66 (70.2)	0.70
RCA	136 (80.5)	95 (73.1)	78 (83.0)	0.15
Proximal or mid	153 (90.5)	107 (82.3)	81 (86.2)	0.11
Blunt stump	78 (46.2)	49 (37.7)	50 (53.2)	0.07
Calcification	44 (26.0)	25 (19.2)	25 (26.6)	0.30
High collateral flow	127 (75.1)	97 (74.6)	70 (74.5)	0.99
SYNTAX score	34.6 ± 10.4	26.9 ± 8.8	29.1 ± 10.2	<0.01

OMT.VS. PCI.VS. CABG IN MVD CTO

Clinical outcomes of multiple chronic total occlusions in coronary arteries according to three therapeutic strategies: Bypass surgery, percutaneous intervention and medication

Bum Sung Kim [a,b,1], Jeong Hoon Yang [a,1], Woo Jin Jang [a,c], Young Bin Song [a], Joo-Yong Hahn [a], Jin-Ho Choi [a], Wook Sung Kim [d], Young Tak Lee [d], Hyeon-Cheol Gwon [a], Sang Hoon Lee [a], Seung-Hyuk Choi [a,*]



- After matching, CABG better in mortality than MT and better in MACCE than PCI at 48 months due to RR

International Journal of Cardiology 197 (2015) 2–7

CTO PCI VS. CABG IN CTO - 2008-2012

Second-generation drug-eluting stenting versus coronary artery bypass grafting for treatment of coronary chronic total occlusion

Woo Jin Jang (MD, PhD)[a,1], Jeong Hoon Yang (MD, PhD)[b,1], Young Bin Song (MD, PhD)[b], Joo-Yong Hahn (MD, PhD)[b], Woo Jung Chun (MD, PhD)[a], Ju Hyeon Oh (MD, PhD)[a], Wook Sung Kim (MD, PhD)[c], Young Tak Lee (MD, PhD)[c], Cheol Woong Yu (MD, PhD)[d], Hyun Jong Lee (MD)[e], Hyeon-Cheol Gwon (MD, PhD)[b], Seung-Hyuk Choi (MD, PhD)[b,*]

- Retrospective non randomized study, 423 patients
- 232 patients 2nd gen DES vs. 191 CABG patients
- 80.1% of CTO-PCI were successfully revascularized
- 92.1% of CTO-CABG were successfully revascularized
- Total arterial graft was performed in 75.3%

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https://doi.org/10.1016/j.jjcc.2018.12.008

CTO PCI VS. CABG IN CTO - 2008-2012

	Overall population $n=423$	2nd DES group $n=232$	CABG group $n=191$	p-Value
Age (years)	63.0 ± 10.6	63.1 ± 11.1	62.9 ± 9.9	0.821
Male	346 (81.8)	186 (80.2)	160 (83.8)	0.340
Diabetes mellitus	209 (49.4)	97 (41.8)	112 (58.6)	0.001
Hypertension	273 (64.5)	151 (65.1)	122 (63.9)	0.805
Dyslipidemia	188 (44.4)	118 (50.9)	70 (36.6)	0.003
Current smoker	134 (31.7)	77 (33.2)	57 (29.8)	0.462
Chronic renal failure	33 (7.8)	16 (6.9)	17 (8.9)	0.444
Acute coronary syndrome	116 (27.4)	82 (35.3)	34 (17.8)	<0.001
Previous MI	64 (15.1)	33 (14.2)	31 (16.2)	0.567
Previous CVA	30 (7.1)	15 (6.5)	15 (7.9)	0.580
Previous PCI	73 (17.3)	43 (18.5)	30 (15.7)	0.444
LVEF *(%)*	54.4 ± 13.8	56.5 ± 13.1	52.0 ± 14.3	0.001
Concomitant medications				
Aspirin	394 (93.1)	222 (95.7)	172 (90.1)	0.022
Statins	334 (79.0)	185 (79.7)	149 (78.0)	0.664
Beta blockers	285 (67.4)	141 (60.8)	14 (75.4)	0.001
ACE inhibitor/ARBs	175 (41.4)	140 (60.3)	35 (18.3)	<0.001

	Overall population $n=423$	2nd DES group $n=232$	CABG group $n=191$	p-Value
CTO location				
Right coronary artery	214 (50.6)	96 (41.4)	118 (61.8)	<0.001
Left main artery	0 (0)	0 (0)	0 (0)	
Left anterior descending artery	160 (37.8)	92 (39.7)	68 (35.6)	0.392
Left circumflex artery	160 (37.8)	77 (33.2)	83 (43.5)	0.030
Multiple CTOs	120 (28.4)	50 (21.6)	70 (36.6)	0.001
Abrupt stump	155 (36.6)	67 (28.9)	88 (46.1)	<0.001
Bridge collaterals	141 (33.3)	56 (24.1)	85 (44.5)	<0.001
Calcified CTO	83 (19.6)	28 (12.1)	55 (28.8)	<0.001
[a]Proximal to mid CTO	308 (72.8)	169 (72.8)	139 (72.8)	0.987
[b]Well-developed collateral	157 (44.4)	75 (46.0)	82 (42.9)	0.561
SYNTAX score	26.3 ± 10.8	22.2 ± 9.5	29.8 ± 10.6	<0.001
SYNTAX score ≥24	197 (55.6)	66 (40.5)	131 (68.6)	<0.001

Non homogeneous groups

J Cardiol. 2019 Jan 2. pii: S0914-5087(18)30351-4.

CTO PCI VS. CABG IN CTO - 2008-2012

	Overall population $n=423$	2nd DES group $n=232$	CABG group $n=191$	[a]Adjusted HR (95% CI)	*p*-Value	HR after IPTW (95% CI)	*p*-Value
Death or MI	21 (5.0)	8 (3.4)	13 (6.8)	0.69 (0.29–1.63)	0.399	0.72 (0.26–1.95)	0.518
Death	19 (4.5)	6 (2.6)	13 (6.8)	0.52 (0.20–1.31)	0.165	0.54 (0.18–1.63)	0.278
Cardiac death	8 (1.9)	2 (0.9)	6 (3.1)	0.45 (0.11–1.81)	0.259	0.39 (0.07–2.15)	0.281
MI	4 (0.9)	3 (1.3)	1 (0.5)	4.28 (0.46–39.74)	0.202	2.94 (0.22–39.85)	0.418
CVA	13 (3.1)	3 (1.3)	10 (5.2)	0.31 (0.08–1.13)	0.077	0.60 (0.15–2.44)	0.477
Repeat revascularization	21 (5.0)	20 (8.6)	1 (0.5)	19.56 (2.59–147.82)	0.004	28.66 (3.50–235.06)	0.002
[b]MACCE	49 (11.6)	28 (12.1)	21 (11.0)	1.32 (0.74–2.35)	0.341	1.49 (0.76–2.91)	0.244

- Mortality similar in this sample
- RR differs at 32 months

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RESIDUAL SYNTAX SCORE IN MVD CTO

Clinical implications of residual SYNTAX score after percutaneous coronary intervention in patients with chronic total occlusion and multivessel coronary artery disease: a comparison with coronary artery bypass grafting

- Retrospective non randomized study in MVD and CTO, 1043 patients (595 PCI, 448 CABG)

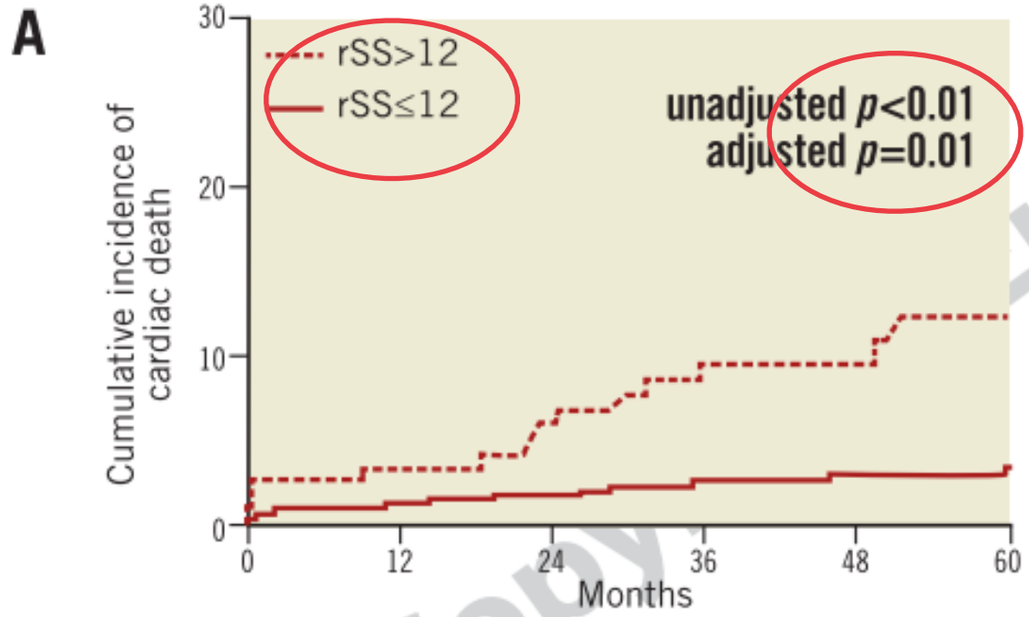
- Compared long term results in CTO-PCI with residual SS <12, > 12 and patients treated with state of the art CABG.

EuroIntervention 2017;13:97-105

RESIDUAL SYNTAX SCORE

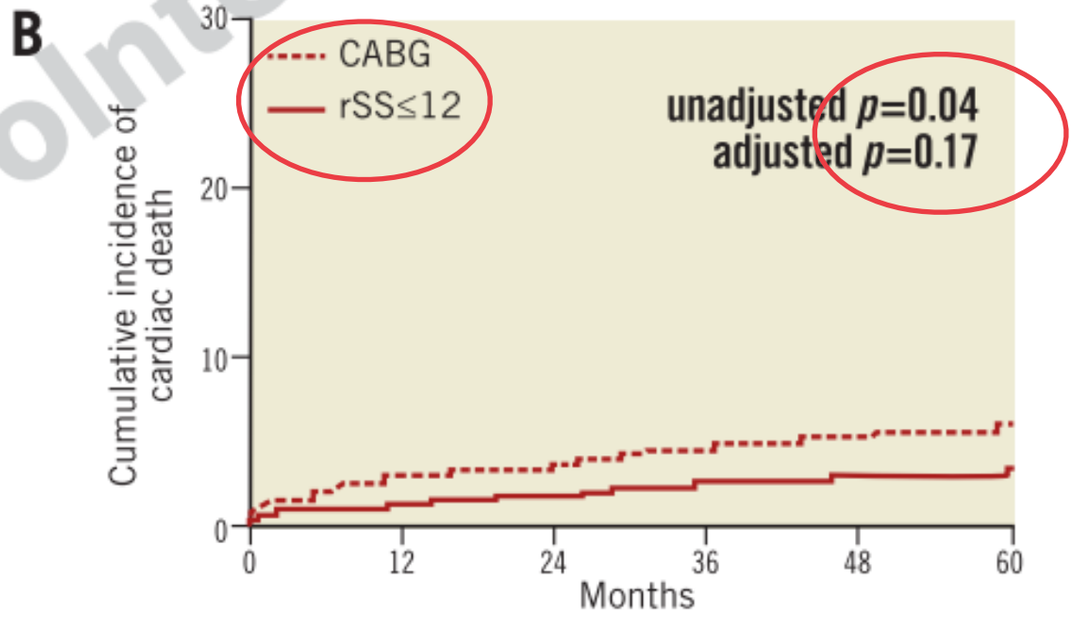
		rSS≤12* n=445	rSS>12* n=150	CABG* n=448	*p*-value rSS≤12 vs. rSS>12	rSS≤12 vs. CABG
Age, years		62.0±10.6	63.6±10.3	62.9±9.2	0.09	0.17
Male		362 (81.3)	120 (80.0)	373 (83.3)	0.72	0.45
Diabetes mellitus		203 (45.6)	74 (49.3)	266 (59.4)	0.43	<0.01
Hypertension		293 (65.8)	103 (68.7)	287 (64.1)	0.53	0.58
Dyslipidaemia		160 (36.0)	39 (26.0)	163 (36.4)	0.03	0.89
Chronic renal failure		31 (7.0)	17 (11.3)	28 (6.2)	0.09	0.67
Acute coronary syndrome		112 (25.2)	38 (25.3)	100 (22.3)	0.97	0.32
Current smoker		141 (31.7)	50 (33.3)	143 (31.9)	0.71	0.94
Previous MI		75 (16.9)	39 (26.0)	103 (23.0)	0.01	0.02
Previous CVA		37 (8.3)	13 (8.7)	40 (8.9)	0.89	0.74
Previous PCI		76 (17.1)	34 (22.7)	72 (16.1)	0.13	0.67
LVEF (%)		58.0±12.0	56.3±14.0	52.8±13.9	0.21	<0.01
CTO location	RCA	192 (43.1)	89 (59.3)	285 (63.6)	<0.01	<0.01
	LAD	167 (37.5)	64 (42.7)	183 (40.8)	0.26	0.31
	LCx	169 (38.0)	48 (32.0)	172 (38.4)	0.19	0.90
	LMCA	0 (0)	0 (0)	0 (0)		
Multiple CTOs		82 (18.4)	48 (32.0)	169 (37.7)	<0.01	<0.01
Abrupt stump		171 (38.4)	67 (44.7)	199 (44.4)	0.18	0.07
Bridge collaterals		138 (31.0)	50 (33.3)	195 (43.5)	0.60	<0.01
Calcified CTO		68 (15.3)	36 (24.0)	110 (24.6)	0.02	<0.01
Proximal-to-mid CTO**		307 (69.0)	117 (78.0)	353 (78.8)	0.04	<0.01
Well-developed collateral***		170 (38.2)	54 (36.0)	157 (35.0)	0.63	0.33
Baseline SYNTAX score		20.6±8.5	26.1±7.8	30.3±10.3	<0.01	<0.01
Concomitant medications	Aspirin	414 (93.0)	137 (91.3)	402 (89.7)	0.49	0.08
	Clopidogrel	424 (95.3)	121 (80.7)	139 (31.0)	<0.01	<0.01
	Statins	328 (73.7)	105 (70.0)	368 (82.1)	0.38	<0.01
	Beta-blockers	255 (57.3)	95 (63.3)	307 (68.5)	0.19	<0.01

RESIDUAL SYNTAX SCORE



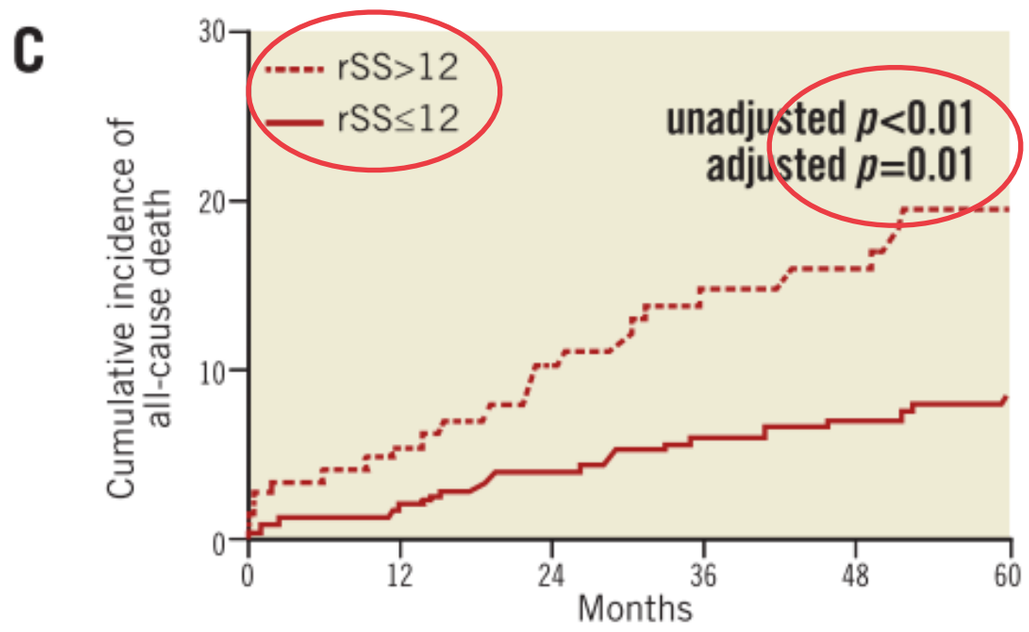
No. at risk

rSS>12	150	134	109	88	75	51
rSS≤12	445	406	353	281	222	169



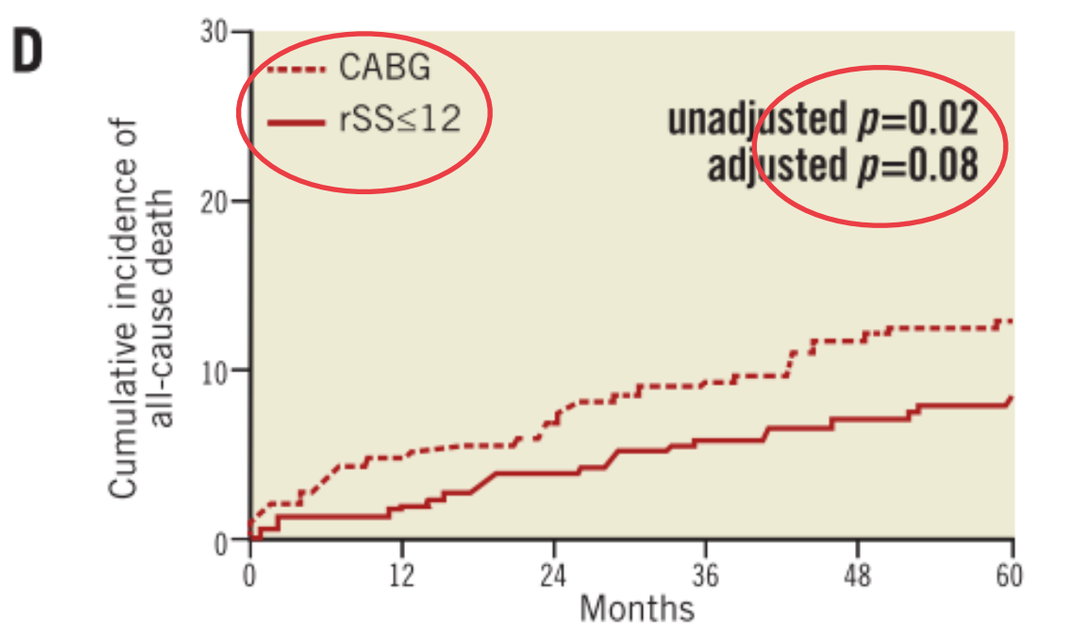
No. at risk

CABG	448	406	350	297	247	204
rSS≤12	445	406	353	281	222	169



No. at risk

rSS>12	150	134	109	88	75	51
rSS≤12	445	406	353	281	222	169



No. at risk

CABG	448	406	350	297	247	204
rSS≤12	445	406	353			

RESIDUAL SYNTAX SCORE

n=445	CR-PCI¶ n=161	reasonable iCR-PCI¶ n=284	Unadjusted HR (95% CI)	*p*-value	Adjusted* HR (95% CI)	*p*-value
Cardiac death	3 (1.9)	11 (3.9)	0.49 (0.14-1.75)	0.27	0.48 (0.13-1.72)	0.26
All-cause death	11 (6.8)	22 (7.7)	0.90 (0.43-1.85)	0.77	0.89 (0.43-1.84)	0.75
MI	3 (1.9)	3 (1.1)	1.81 (0.36-8.95)	0.47	1.82 (0.36-9.15)	0.47
CVA	2 (1.2)	3 (1.1)	1.18 (0.20-7.06)	0.86	1.44 (0.23-8.95)	0.70
Repeat revascularisation	21 (13.0)	35 (12.3)	1.05 (0.61-1.80)	0.86	1.09 (0.63-1.88)	0.76
MACCE	30 (18.6)	58 (20.4)	0.91 (0.58-1.41)	0.67	0.93 (0.60-1.45)	0.76
n=609	**CR-PCI¶ n=161**	**CABG n=448**	**Unadjusted HR (95% CI)**	***p*-value**	**Adjusted** HR (95% CI)**	***p*-value**
Cardiac death	3 (1.9)	29 (6.5)	0.31 (0.09-1.00)	0.05	0.37 (0.11-1.24)	0.11
All-cause death	11 (6.8)	59 (13.2)	0.56 (0.29-1.06)	0.08	0.62 (0.32-1.20)	0.16
MI	3 (1.9)	2 (0.4)	4.31 (0.72-25.80)	0.11	5.17 (0.80-33.38)	0.09
CVA	2 (1.2)	18 (4.0)	0.33 (0.08-1.44)	0.14	0.43 (0.10-1.86)	0.26
Repeat revascularisation	21 (13.0)	4 (0.9)	16.89 (5.78-49.31)	<0.01	14.51 (4.90-42.99)	<0.01
MACCE	30 (18.6)	86 (19.2)	1.13 (0.74-1.71)	0.57	1.21 (0.79-1.85)	0.38
n=732	**reasonable iCR-PCI¶ n=284**	**CABG n=448**	**Unadjusted HR (95% CI)**	***p*-value**	**Adjusted*** HR (95% CI)**	***p*-value**
Cardiac death	11 (3.9)	29 (6.5)	0.63 (0.32-1.27)	0.20	0.76 (0.37-1.55)	0.45
All-cause death	22 (7.7)	59 (13.2)	0.63 (0.39-1.03)	0.06	0.71 (0.43-1.18)	0.18
MI	3 (1.1)	2 (0.4)	2.50 (0.42-14.99)	0.32	3.68 (0.57-23.90)	0.17
CVA	3 (1.1)	18 (4.0)	0.27 (0.08-0.93)	0.04	0.33 (0.09-1.16)	0.08
Repeat revascularisation	35 (12.3)	4 (0.9)	16.42 (5.83-46.26)	<0.01	18.21 (6.32-52.48)	<0.01
MACCE	58 (20.4)	86 (19.2)	1.26 (0.90-1.75)	0.18	1.41 (1.01-2.00)	0.06

EuroIntervention 2017;13:97-105

RESIDUAL SYNTAX SCORE

Clinical implications of residual SYNTAX score after percutaneous coronary intervention in patients with chronic total occlusion and multivessel coronary artery disease: a comparison with coronary artery bypass grafting

- CABG - more sick patients, higher baseline SS
- Mortality in residual SS<12 similar to CABG
- Repeat revascularization higher (13% vs. 1%) in residual Syntax Score 0-12
- Unfortunately, no TTF measurements and no "residual SS in CABG" patients reported

EuroIntervention 2017;13:97-105

LIKELY TECHNIQUE OF CTO PCI

- Avoid probable retrograde technique or other complex crossing techniques?
- Avoid in very high SS-CTO or J—CTO scores?
- Avoid in long(>20 mm) CTO´s?
- Avoid in patients with residual SS > 12? And < 12?

CONCLUSIONS

- "Broadly speaking, the treatment of CTOs may be considered analogous to the treatment of non-CTO lesions."

- Some anatomical and clinical caracteristics, as well as patient preference, may help decision making in treating MVD with CTO

- Age and gender also influence success of both revascularization strategies and should be considered

- CTO PCI in MVD is feasible - but is it advisable in all? What is the expected residual SS and crossing technique?

ROLE OF CABG IN MVD CTO

- CABG has very little technical modifications if the patient has MVD CTO

- Evidence is favorable to CABG even in sicker patients, mainly due to diminished RR

CONCLUSIONS

- Repeat revascularization continues to be a problem in all PCI (and reabsorbable stents are not the solution we hoped they would be)

- More complex MVD CTO patients should continue to undergo state of the art CABG

- In the absence of robust evidence, MVD with CTO should continue to be treated with CABG if no other contraindications exist.

Thank you

Coração e Vasos
DEPARTAMENTO DE CORAÇÃO E VASOS
DO CENTRO HOSPITALAR LISBOA NORTE

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