Which CTO should be intervented?

beyond guidline indications

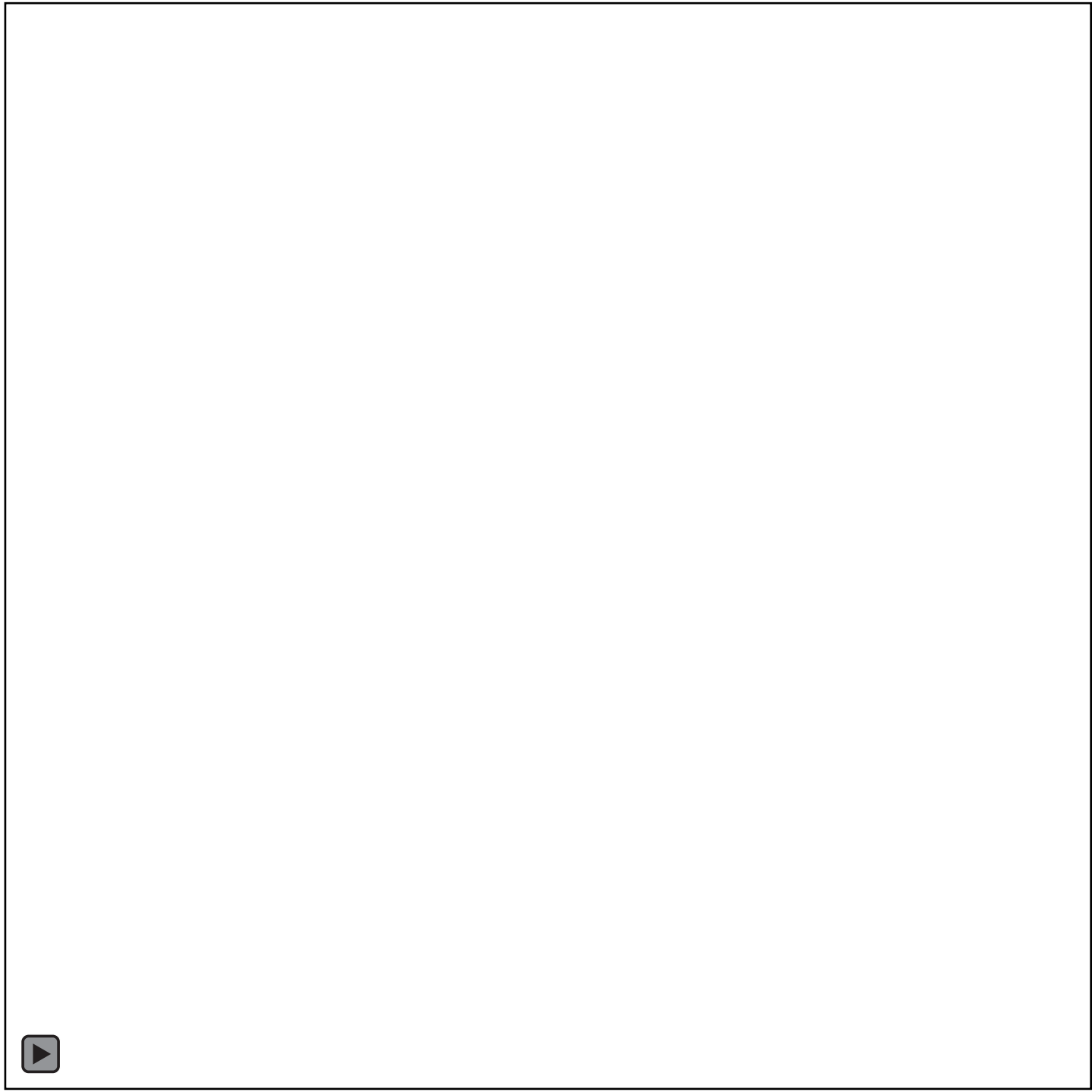
Uzeyir RAHIMOV, MD, PhD, FSCAI, FESC.

Head of Azerbaijan Society of Cardiology

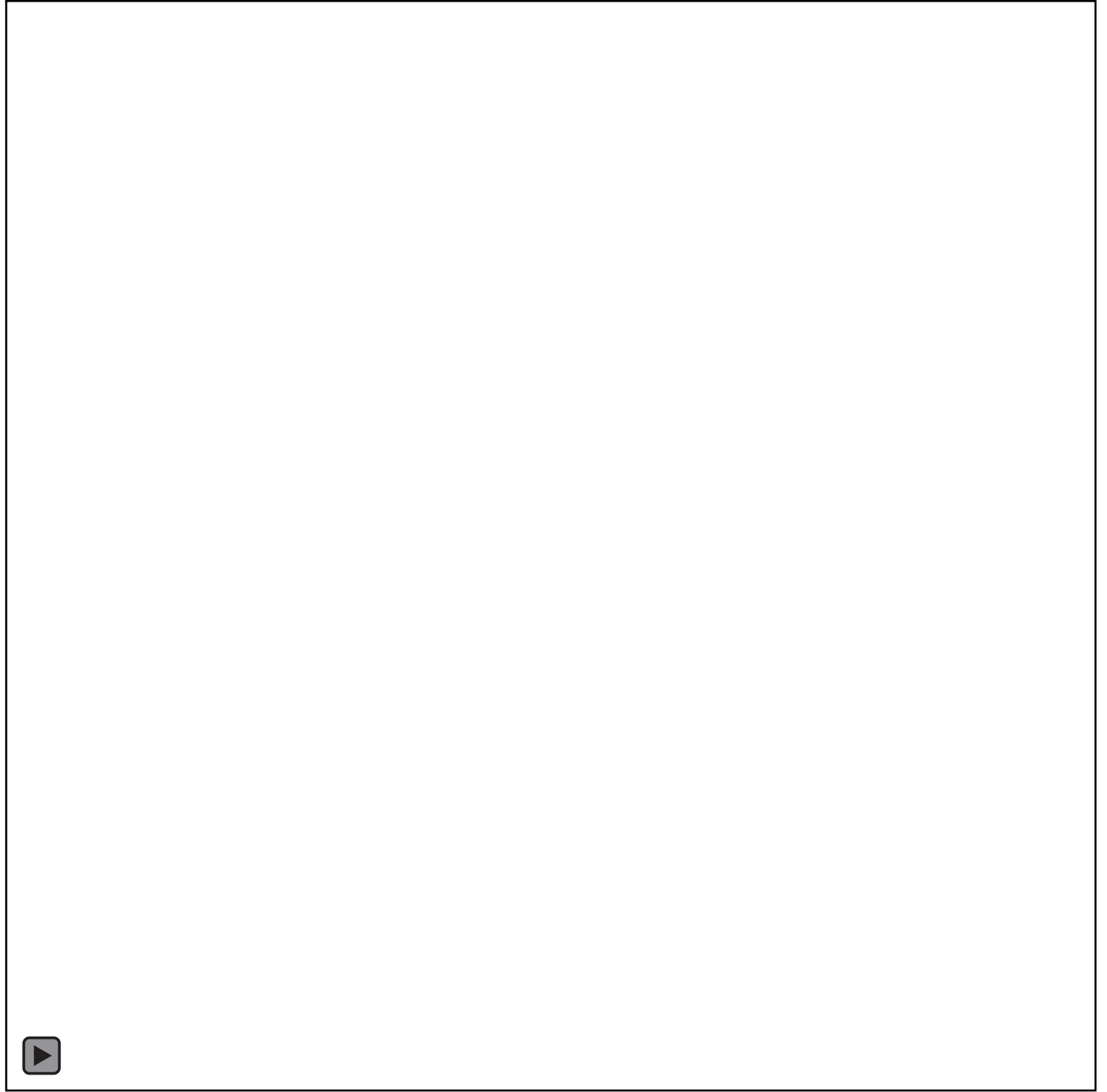
CASE Presentation

- 65y.o. Male
- Angina free
- HT, DM, Obese (145kg), Hlip, TIA, minor phys. activity
- Previous inf-post MI - ? years ago
- LVEF – 45%
- 2016 LAD PCI
- Admitted for carotis angioplasty (2017)

2017 Angiography

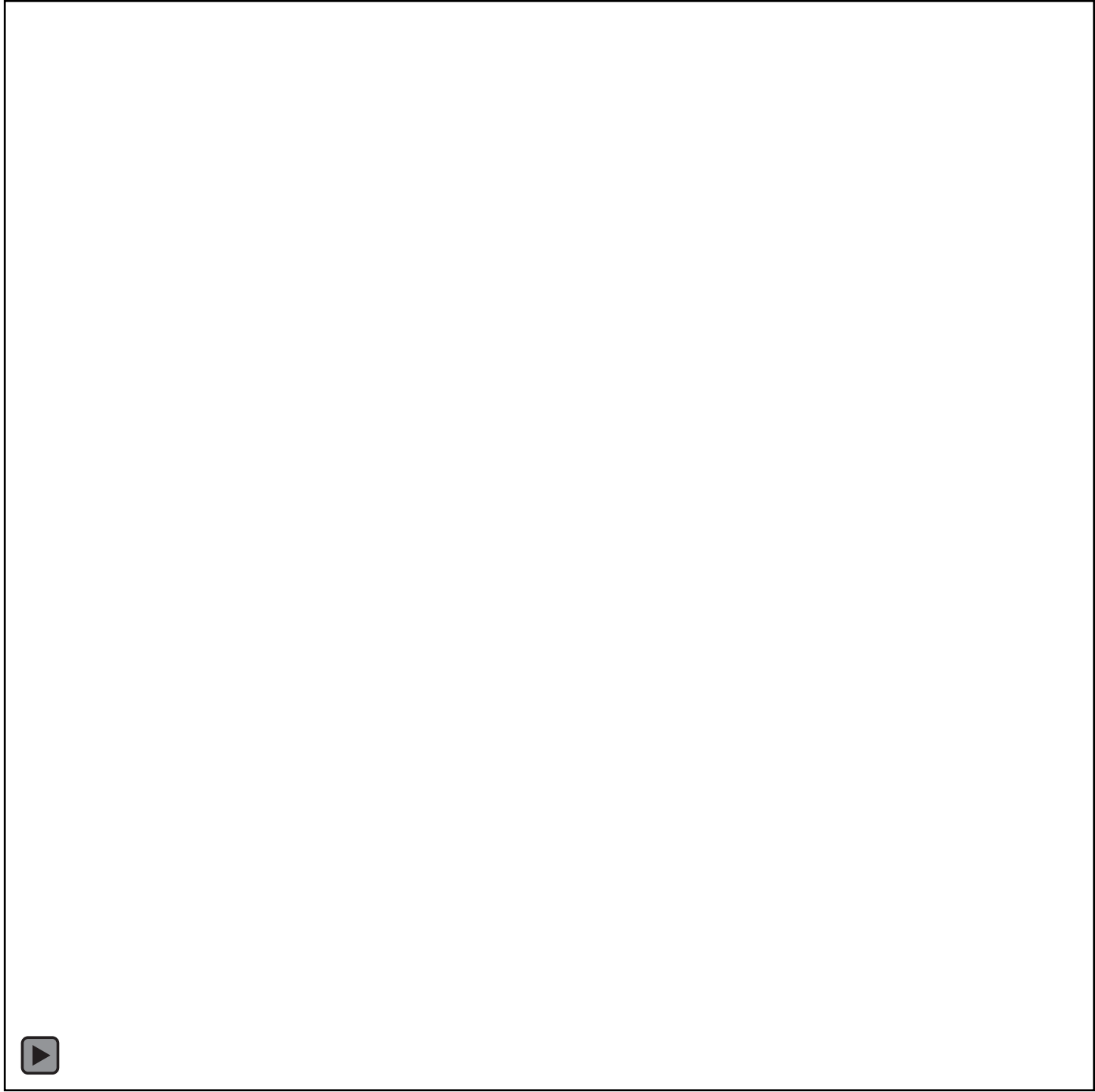


2017 LAD PCI

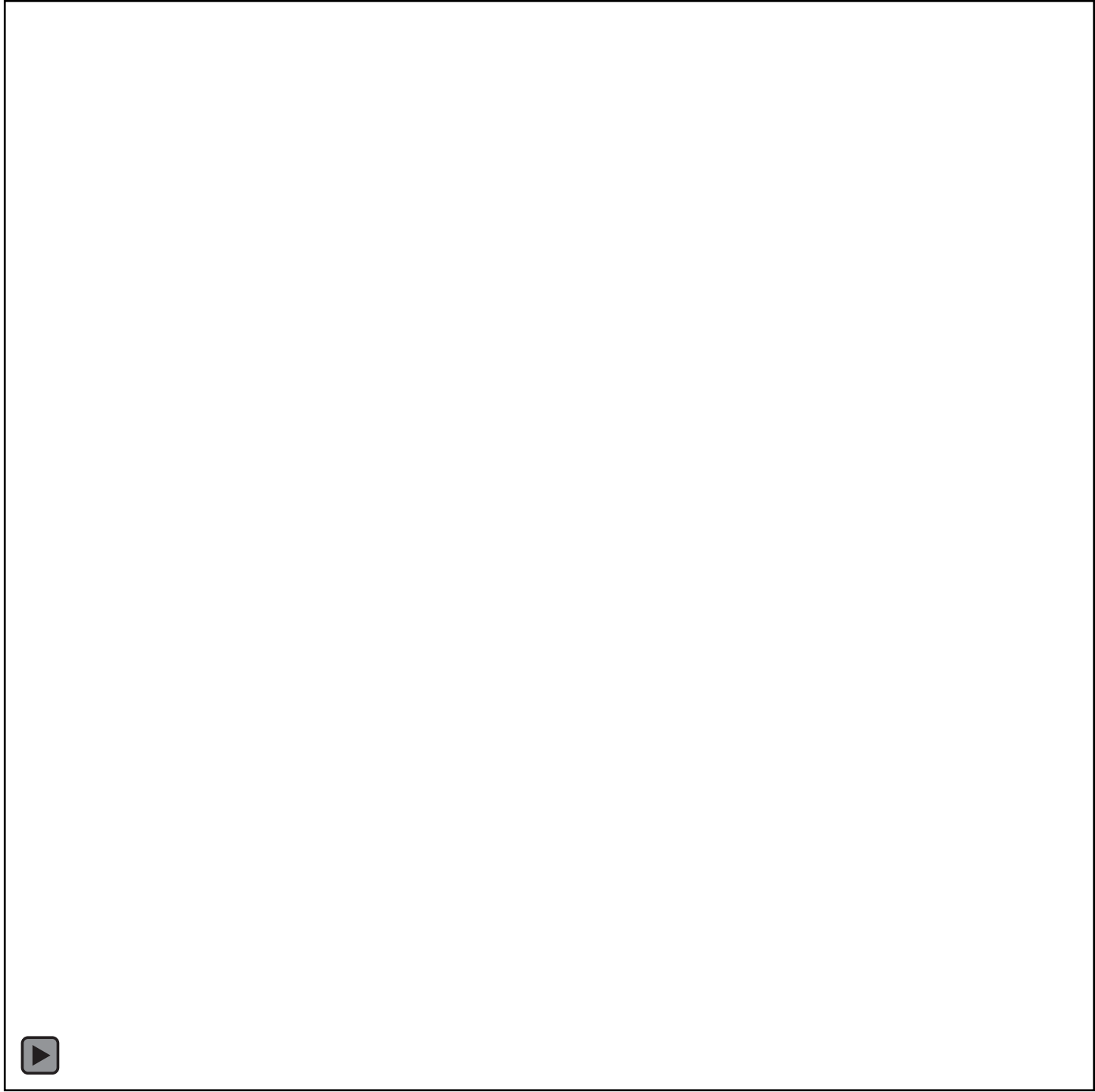


2023 Angiography
(presented with NSTEMI)

LVEF= 30%



2023 LAD PCI



What should be the next step?

- CX – RCA PCI?
- OMT?

CTOs are a common finding, present in 18-52% of the patients with coronary artery disease who undergo coronary angiography

Jeroudi OM, Alomar ME, Michael TT, El Sabbagh A, Patel VG, Mogabgab O, et al. Prevalence and management of coronary chronic total occlusions in a tertiary Veterans Affairs hospital. Catheter Cardiovasc Interv 2014;84 (4):637–43

The presence of a CTO is independently associated with poorer prognosis, with an almost 2.9-fold increased risk of mortality in patients presenting with a STEMI and concurrent CTO

Allahwala UK, Jolly SS, Dzavik V, Cairns JA, Kedev S, Balasubramanian K, et al. The Presence of a CTO in a Non-Infarct-Related Artery During a STEMI Treated With Contemporary Primary PCI Is Associated With Increased Rates of Early and Late Cardiovascular Morbidity and Mortality: The CTO-TOTAL Substudy. JACC Cardiovasc Interv 2018;11 (7):709–11.

What guidelines say?

ACC/AHA/SCAI CLINICAL PRACTICE GUIDELINE

2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines

10.7. Treatment of CTO

Recommendation for Treatment of CTO
Referenced studies that support the recommendation are summarized in Online Data Supplement 29.

COR	LOE	Recommendation
2b	B-R	1. In patients with suitable anatomy who have refractory angina on medical therapy, after treatment of non-CTO lesions, the benefit of PCI of a CTO to improve symptoms is uncertain.[1-4]

What guidelines say?

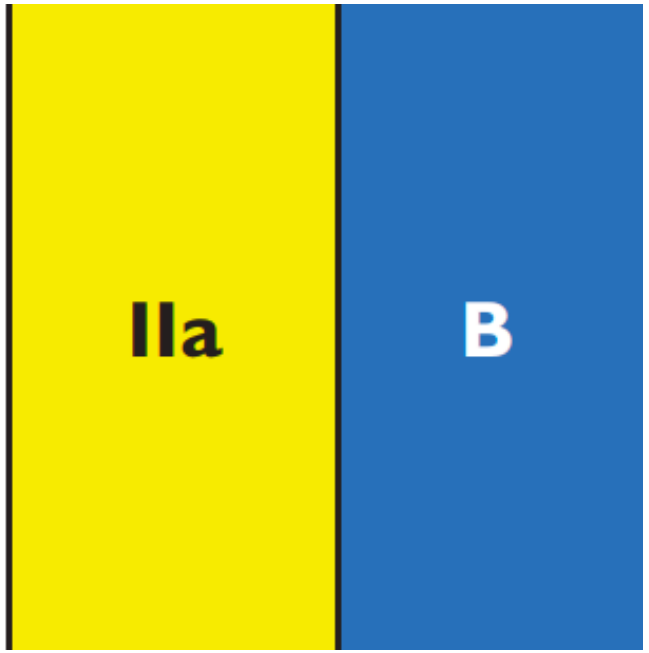
ESC European Society of Cardiology
European Heart Journal (2019) **40**, 87–165
doi:10.1093/eurheartj/ehy394

ESC/EACTS GUIDELINES

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)

Percutaneous revascularization of CTOs should be considered in patients with angina resistant to medical therapy or with a large area of documented ischaemia in the territory of the occluded vessel.[629,659–663]



Arguments against opening CTOs

- ✓It is already occluded and can’t get any worse
- ✓It is worthless to open because most of the muscle must already be non-viable
- ✓There is no need to intervene even if there is viable myocardium because the collateral circulation will suffice

Counter argument

- ✓CTOs frequently serve viable myocardium and they are all flow limiting

Indications for opening CTOs

- Improving symptoms and quality of life
- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

- Improving symptoms and quality of life

- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

Open-CTO registry

EURO-CTO trial

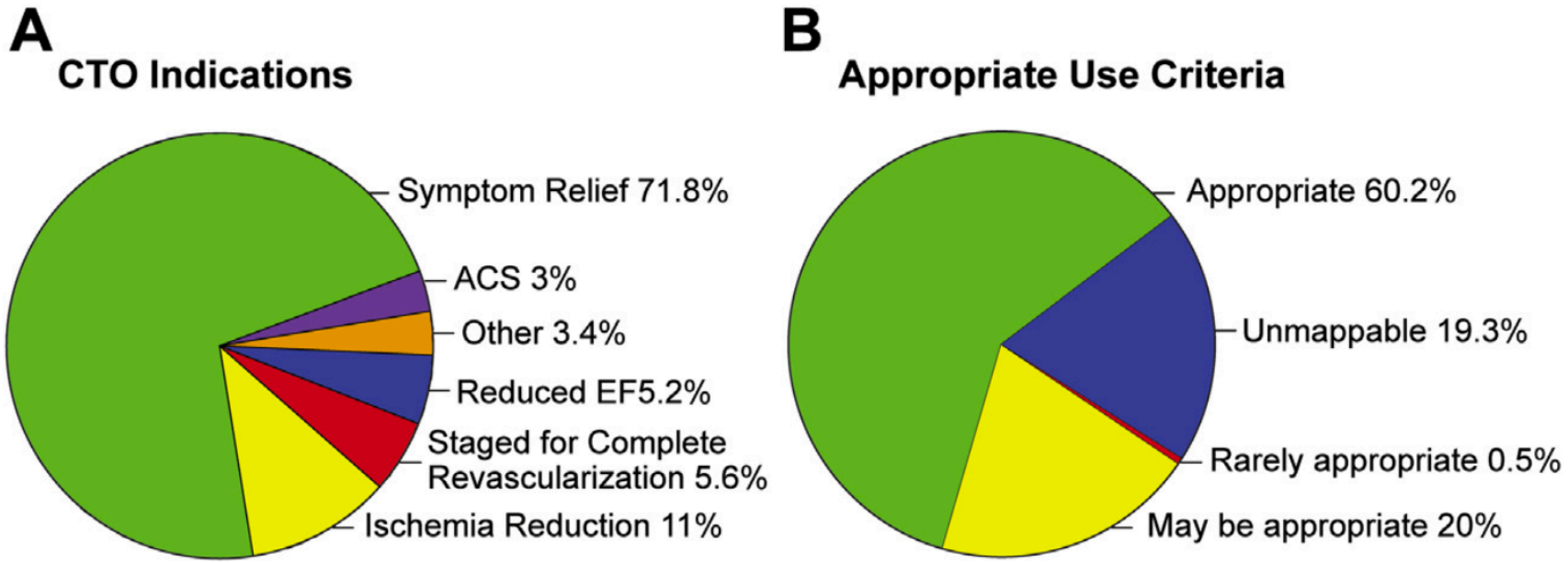
• Improving symptoms and quality of life

- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

Open-CTO registry

Early Procedural and Health Status Outcomes After Chronic Total Occlusion Angioplasty

A Report From the OPEN-CTO Registry (Outcomes, Patient Health Status, and Efficiency in Chronic Total Occlusion Hybrid Procedures)



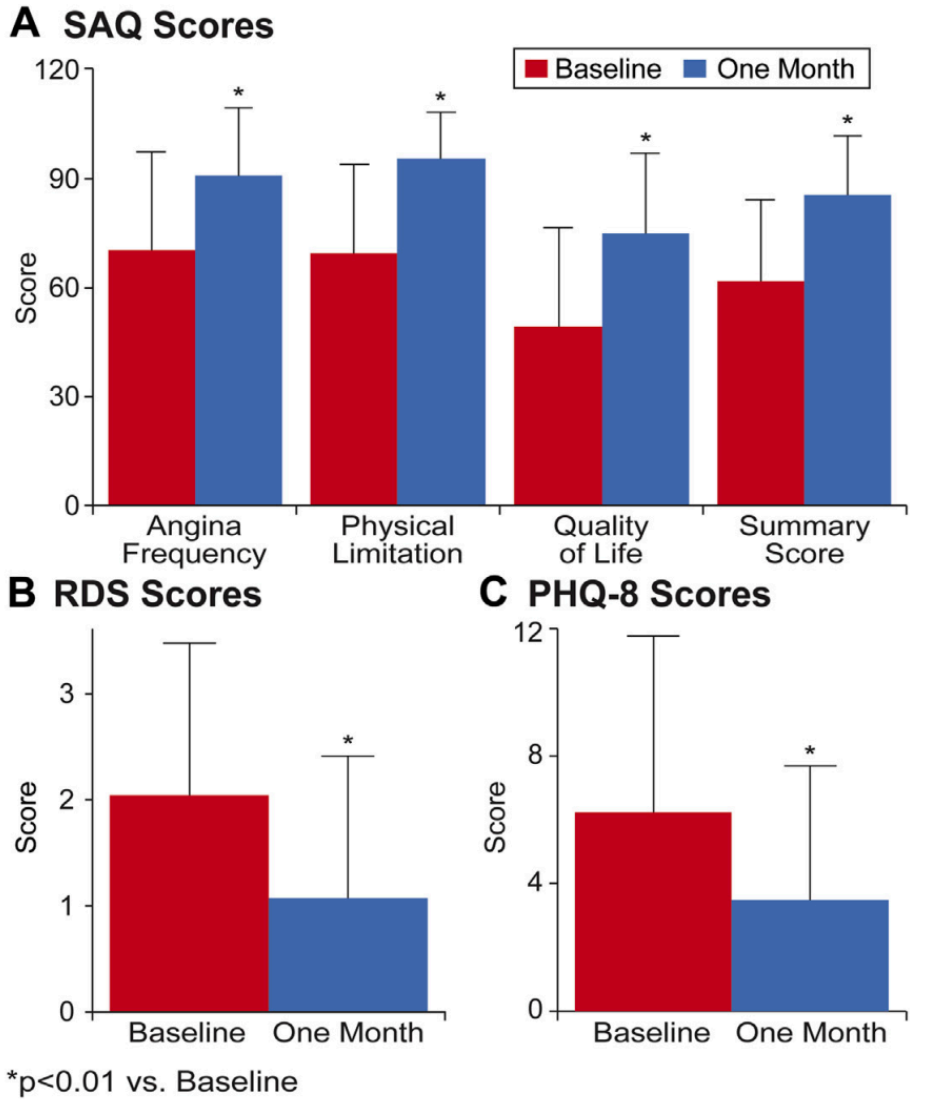
Distributions of the indications **(A)** for and appropriateness ratings **(B)** of the procedures. ACS = acute coronary syndrome; CTO = chronic total occlusion; EF = ejection fraction.

http://dx.doi.org/10.1016/j.jcin.2017.05.065

• Improving symptoms and quality of life

Open-CTO registry

- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions
- Improving left ventricular function



Unadjusted mean ± SEM health status scores at baseline and 1 month among those with paired data (n = 890). PHQ-8 = Physicians Health Questionnaire 8; RDS = Rose Dyspnea Scale; SAQ = Seattle Angina Questionnaire.

http://dx.doi.org/10.1016/j.jcin.2017.05.065

• Improving symptoms and quality of life

- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

EURO-CTO trial

ESC European Society of Cardiology
European Heart Journal (2018) 39, 2484–2493
doi:10.1093/eurheartj/ehy220
CLINICAL RESEARCH
Interventional cardiology

A randomized multicentre trial to compare revascularization with optimal medical therapy for the treatment of chronic total coronary occlusions

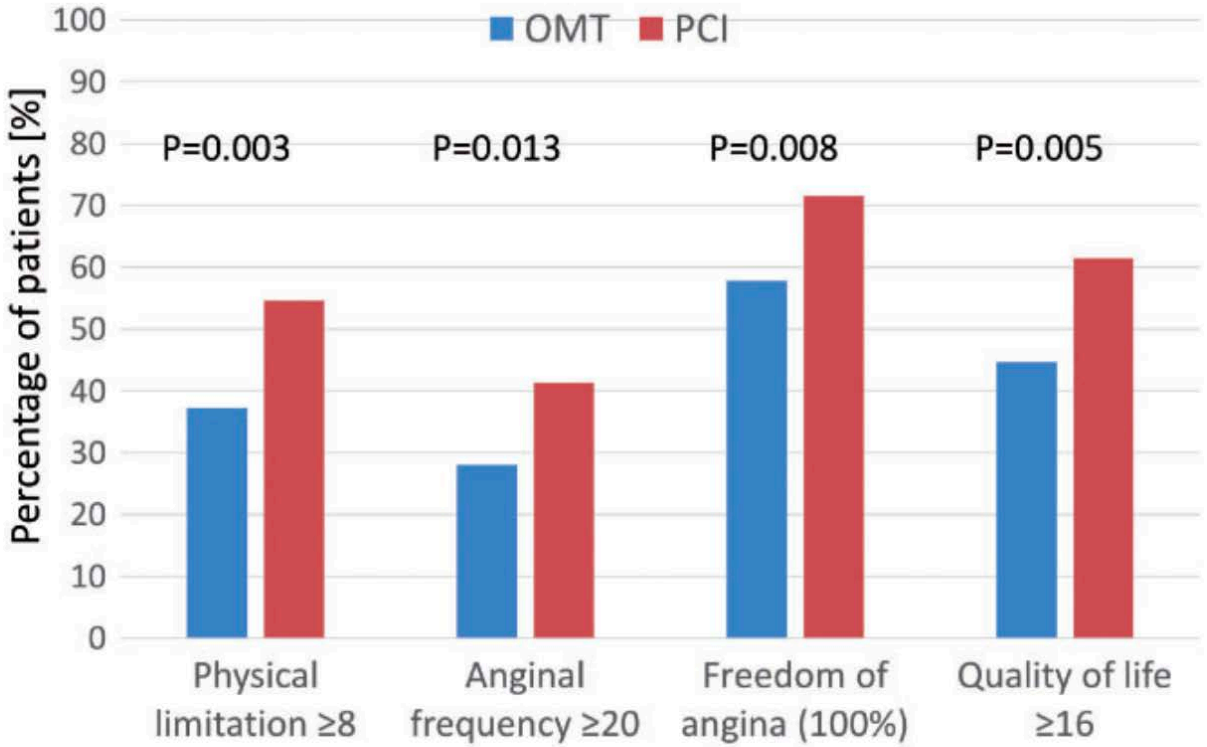


Figure 4 Comparison of significant changes in the Seattle angina questionnaire categories from baseline to follow-up between optimal medical therapy and percutaneous coronary intervention.

doi:10.1093/eurheartj/ehy220

• Improving symptoms and quality of life

- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

SAQ angina frequency				
1 mo	94.63±10.54	93.31±13.78	1.33 (−0.81 to 3.46)	0.23
6 mo	96.00±10.13	95.44±9.98	0.56 (−1.30 to 2.42)	0.56
12 mo	94.55±11.18	95.33±10.19	−0.78 (−2.83 to 1.26)	0.45
24 mo	97.31±7.13	97.18±7.65	0.13 (−1.43 to 1.69)	0.87
36 mo	98.21±5.32	97.38±7.20	0.83 (−0.67 to 2.32)	0.27

SAQ quality of life				
1 mo	66.16±19.87	64.26±19.65	1.90 (−1.55 to 5.35)	0.28
6 mo	72.08±17.54	69.74±17.48	2.34 (−0.90 to 5.58)	0.16
12 mo	72.19±19.06	71.89±16.6	0.30 (−3.12 to 3.71)	0.86
24 mo	77.37±17.43	75.91±17.77	1.45 (−2.25 to 5.16)	0.44
36 mo	78.26±17.39	77.53±16.69	0.73 (−3.26 to 4.72)	0.72

DECISION-CTO Trial

ORIGINAL RESEARCH ARTICLE

Randomized Trial Evaluating Percutaneous Coronary Intervention for the Treatment of Chronic Total Occlusion

The DECISION-CTO Trial

Lee SW, Lee PH, Ahn JM, et al. Randomized Trial Evaluating Percutaneous Coronary Intervention for the Treatment of Chronic Total Occlusion. *Circulation*. 2019;139(14):1674-1683.

• Improving symptoms and quality of life

- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

DECISION-CTO Trial

ORIGINAL RESEARCH ARTICLE

Randomized Trial Evaluating Percutaneous Coronary Intervention for the Treatment of Chronic Total Occlusion

The DECISION-CTO Trial

SAQ treatment satisfaction				
1 mo	83.07±12.75	80.42±15.03	2.66 (0.23 to 5.09)	0.03
6 mo	83.16±13.29	83.13±14.25	0.02 (–2.53 to 2.57)	0.99
12 mo	83.98±13.19	83.26±14.61	0.72 (–1.94 to 3.39)	0.59
24 mo	84.95±12.62	83.28±13.41	1.67 (–1.07 to 4.42)	0.23
36 mo	87.13±11.89	84.00±11.59	3.13 (0.38 to 5.89)	0.03

Lee SW, Lee PH, Ahn JM, et al. Randomized Trial Evaluating Percutaneous Coronary Intervention for the Treatment of Chronic Total Occlusion. *Circulation*. 2019;139(14):1674-1683.

• Improving symptoms and quality of life

- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

DECISION-CTO Trial

ORIGINAL RESEARCH ARTICLE

Randomized Trial Evaluating Percutaneous Coronary Intervention for the Treatment of Chronic Total Occlusion

The DECISION-CTO Trial

SAQ treatment satisfaction				
1 mo	83.07±12.75	80.42±15.03	2.66 (0.23 to 5.09)	0.03
6 mo	83.16±13.29	83.13±14.25	0.02 (–2.53 to 2.57)	0.99
12 mo	83.98±13.19	83.26±14.61	0.72 (–1.94 to 3.39)	0.59
24 mo	84.95±12.62	83.28±13.41	1.67 (–1.07 to 4.42)	0.23
36 mo	87.13±11.89	84.00±11.59	3.13 (0.38 to 5.89)	0.03

Lee SW, Lee PH, Ahn JM, et al. Randomized Trial Evaluating Percutaneous Coronary Intervention for the Treatment of Chronic Total Occlusion. *Circulation*. 2019;139(14):1674-1683.

ISCHEMİA Trial

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 APRIL 9, 2020 VOL. 382 NO. 15

Initial Invasive or Conservative Strategy for Stable Coronary Disease

D.J. Maron, J.S. Hochman, H.R. Reynolds, S. Bangalore, S.M. O'Brien, W.E. Boden, B.R. Chaitman, R. Senior, J. López-Sendón, K.P. Alexander, R.D. Lopes, L.J. Shaw, J.S. Berger, J.D. Newman, M.S. Sidhu, S.G. Goodman, W. Ruzyllo, G. Gosselin, A.P. Maggioni, H.D. White, B. Bhargava, J.K. Min, G.B.J. Mancini, D.S. Berman, M.H. Picard, R.Y. Kwong, Z.A. Ali, D.B. Mark, J.A. Spertus, M.N. Krishnan, A. Elghamaz, N. Moorthy, W.A. Hueb, M. Demkow, K. Mavromatis, O. Bockeria, J. Peteiro, T.D. Miller, H. Szwed, R. Doerr, M. Keltai, J.B. Selvanayagam, P.G. Steg, C. Held, S. Kohsaka, S. Mavromichalis, R. Kirby, N.O. Jeffries, F.E. Harrell, Jr., F.W. Rockhold, S. Broderick, T.B. Ferguson, Jr., D.O. Williams, R.A. Harrington, G.W. Stone, and Y. Rosenberg, for the ISCHEMIA Research Group*

Total 5179 patients: 2588 undergo PCI, 2591receive OMT

Follow up: median 3.2

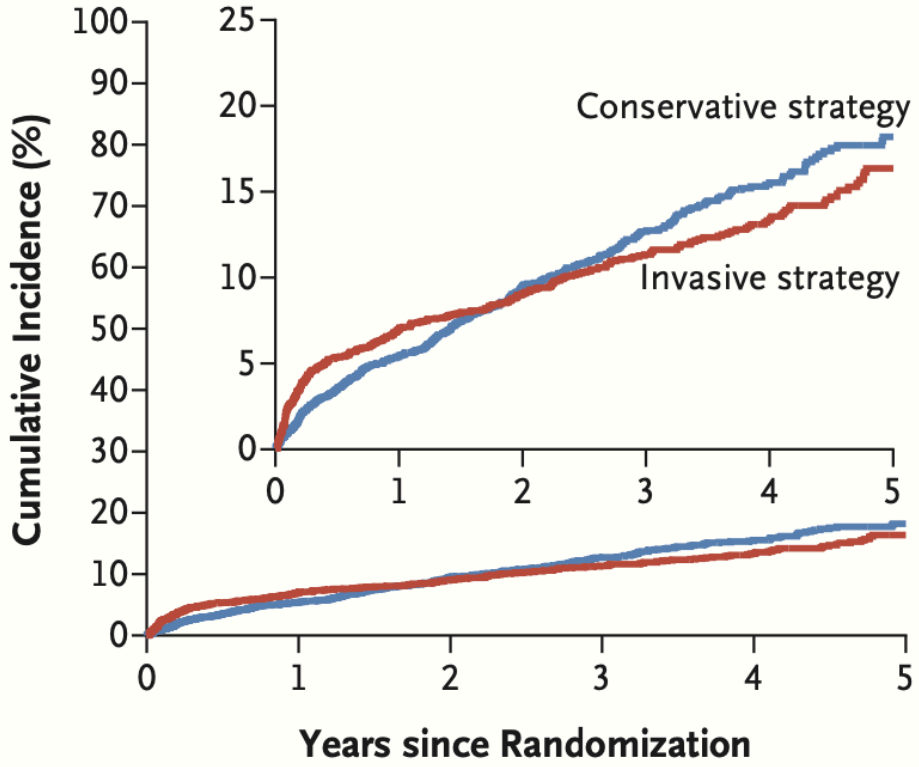
Initial Invasive or Conservative Strategy for Stable Coronary Disease

D.J. Maron, J.S. Hochman, H.R. Reynolds, S. Bangalore, S.M. O'Brien, W.E. Boden, B.R. Chaitman, R. Senior, J. López-Sendón, K.P. Alexander, R.D. Lopes, L.J. Shaw, J.S. Berger, J.D. Newman, M.S. Sidhu, S.G. Goodman, W. Ruzyllo, G. Gosselin, A.P. Maggioni, H.D. White, B. Bhargava, J.K. Min, G.B.J. Mancini, D.S. Berman, M.H. Picard, R.Y. Kwong, Z.A. Ali, D.B. Mark, J.A. Spertus, M.N. Krishnan, A. Elghamaz, N. Moorthy, W.A. Hueb, M. Demkow, K. Mavromatis, O. Bockeria, J. Peteiro, T.D. Miller, H. Szwed, R. Doerr, M. Keltai, J.B. Selvanayagam, P.G. Steg, C. Held, S. Kohsaka, S. Mavromichalis, R. Kirby, N.O. Jeffries, F.E. Harrell, Jr., F.W. Rockhold, S. Broderick, T.B. Ferguson, Jr., D.O. Williams, R.A. Harrington, G.W. Stone, and Y. Rosenberg, for the ISCHEMIA Research Group*

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 APRIL 9, 2020 VOL. 382 NO. 15

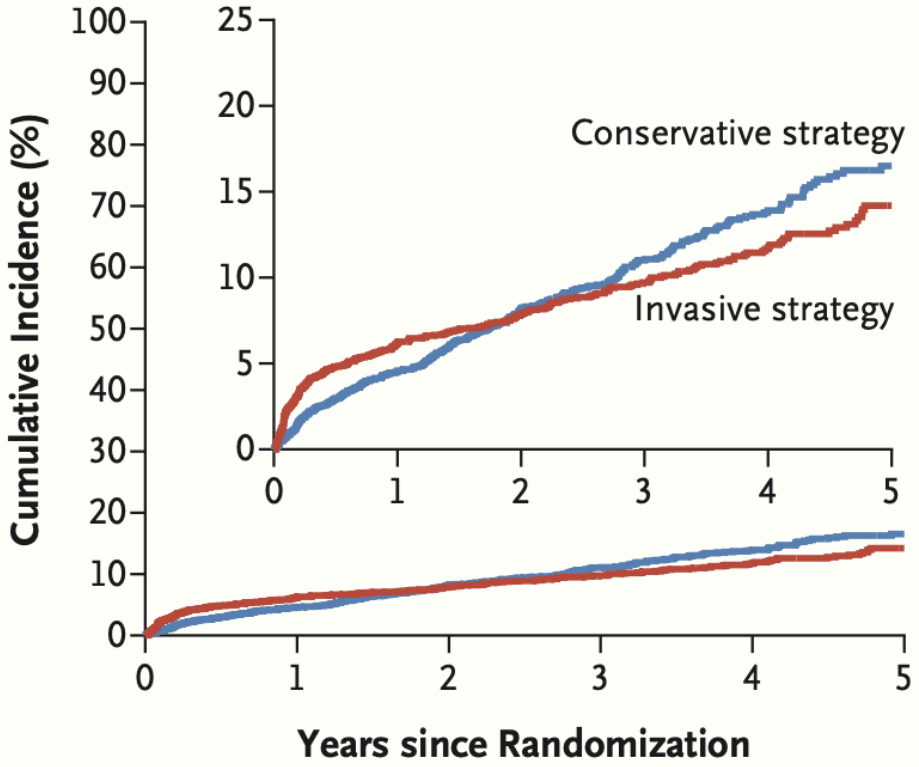
A Primary Composite Outcome



No. at Risk

Conservative strategy	2591	2431	1907	1300	733	293
Invasive strategy	2588	2364	1908	1291	730	271

B Death from Cardiovascular Causes or Myocardial Infarction



No. at Risk

Conservative strategy	2591	2453	1933	1325	746	298
Invasive strategy	2588	2383	1933	1314	742	282

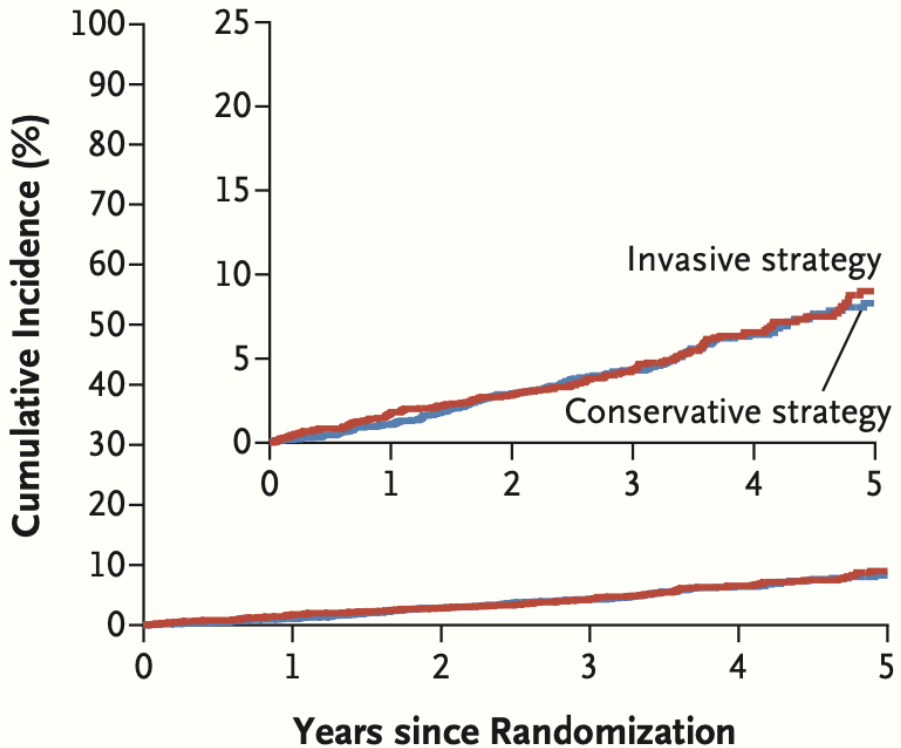
Initial Invasive or Conservative Strategy for Stable Coronary Disease

D.J. Maron, J.S. Hochman, H.R. Reynolds, S. Bangalore, S.M. O'Brien, W.E. Boden, B.R. Chaitman, R. Senior, J. López-Sendón, K.P. Alexander, R.D. Lopes, L.J. Shaw, J.S. Berger, J.D. Newman, M.S. Sidhu, S.G. Goodman, W. Ruzyllo, G. Gosselin, A.P. Maggioni, H.D. White, B. Bhargava, J.K. Min, G.B.J. Mancini, D.S. Berman, M.H. Picard, R.Y. Kwong, Z.A. Ali, D.B. Mark, J.A. Spertus, M.N. Krishnan, A. Elghamaz, N. Moorthy, W.A. Hueb, M. Demkow, K. Mavromatis, O. Bockeria, J. Peteiro, T.D. Miller, H. Szwed, R. Doerr, M. Keltai, J.B. Selvanayagam, P.G. Steg, C. Held, S. Kohsaka, S. Mavromichalis, R. Kirby, N.O. Jeffries, F.E. Harrell, Jr., F.W. Rockhold, S. Broderick, T.B. Ferguson, Jr., D.O. Williams, R.A. Harrington, G.W. Stone, and Y. Rosenberg, for the ISCHEMIA Research Group*

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 APRIL 9, 2020 VOL. 382 NO. 15

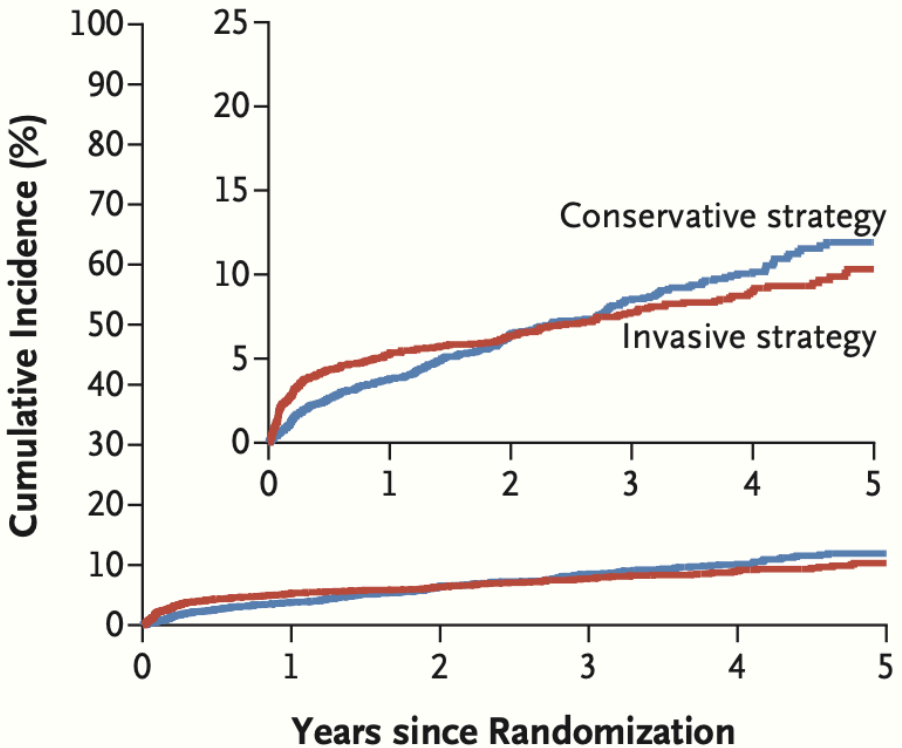
C Death from Any Cause



No. at Risk

Conservative strategy	2591	2548	2065	1445	844	349
Invasive strategy	2588	2518	2061	1431	827	317

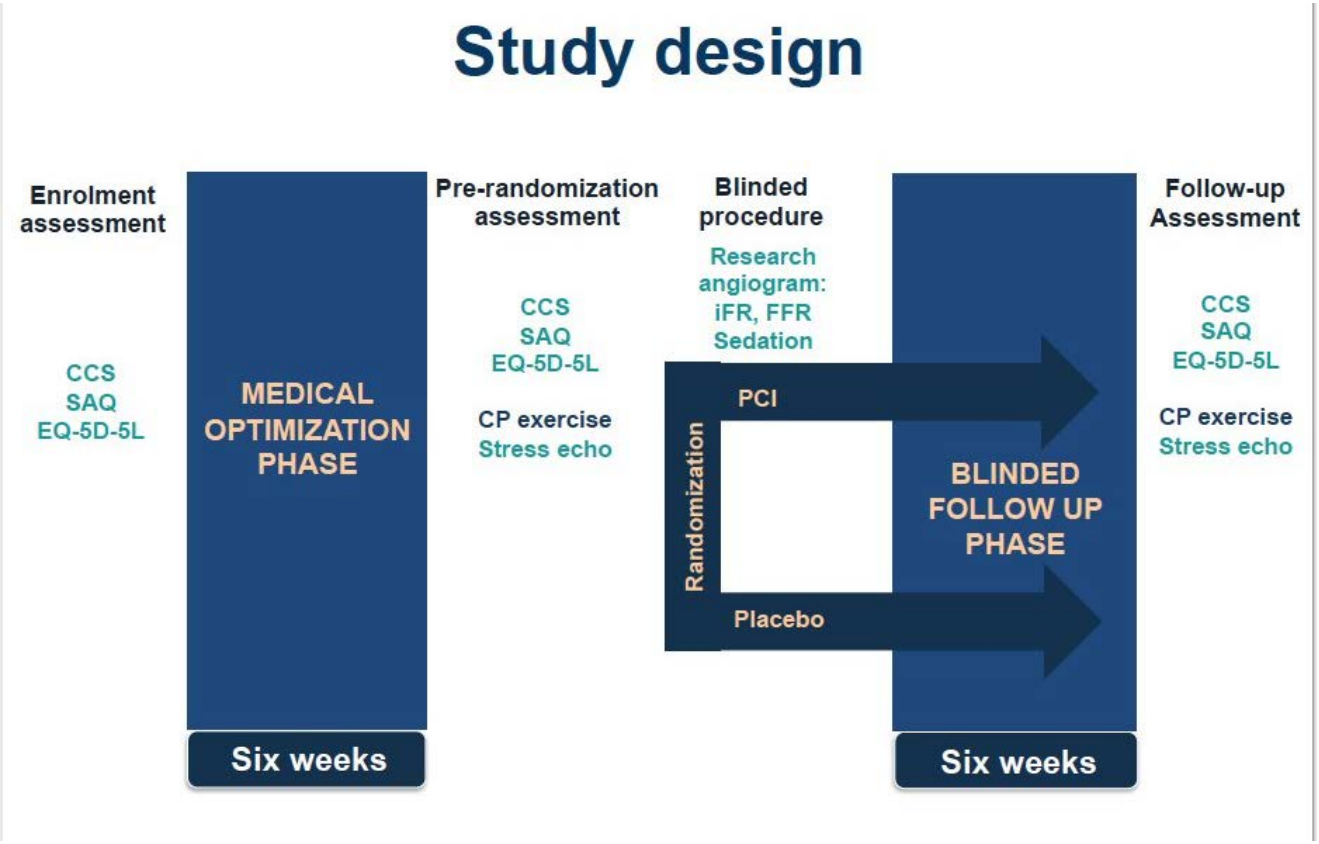
D Myocardial Infarction

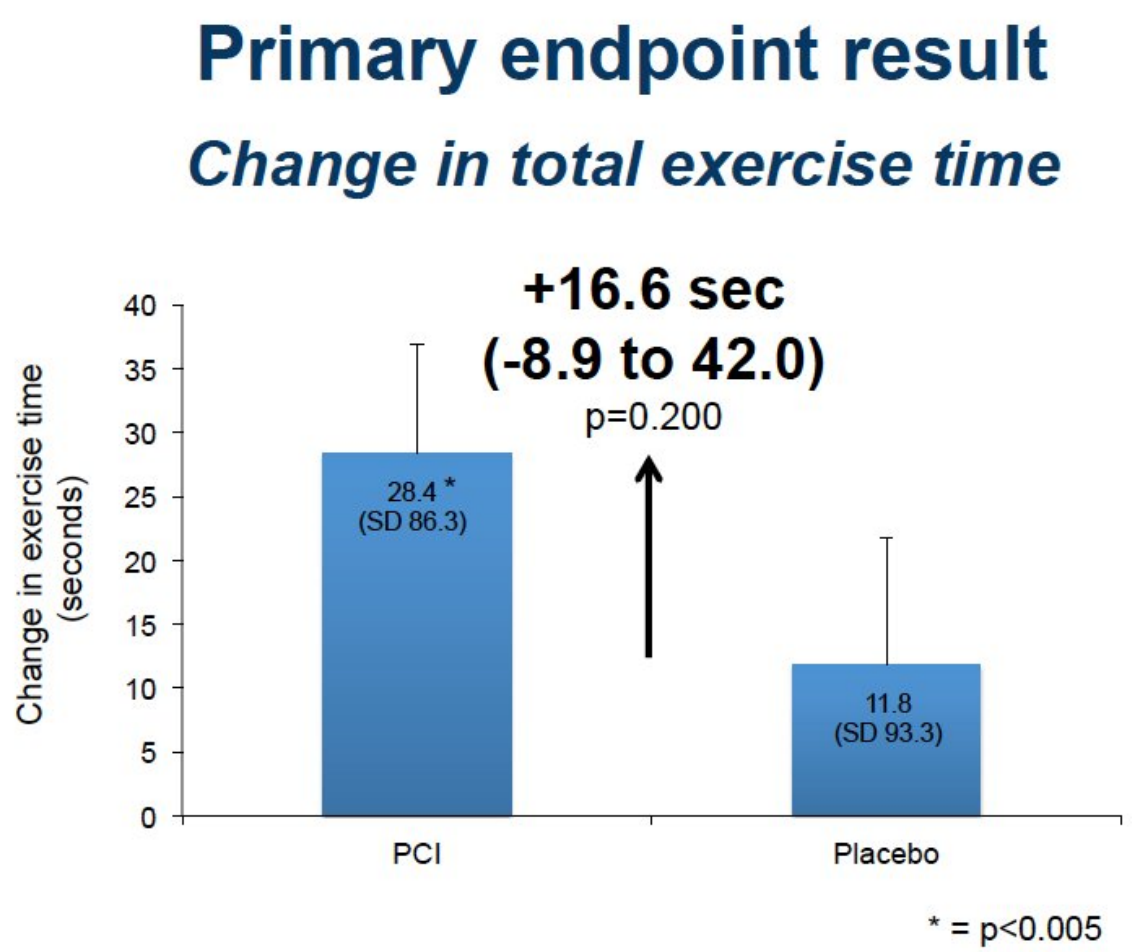


No. at Risk

Conservative strategy	2591	2452	1931	1321	747	298
Invasive strategy	2588	2379	1931	1313	742	283

Orbita trial

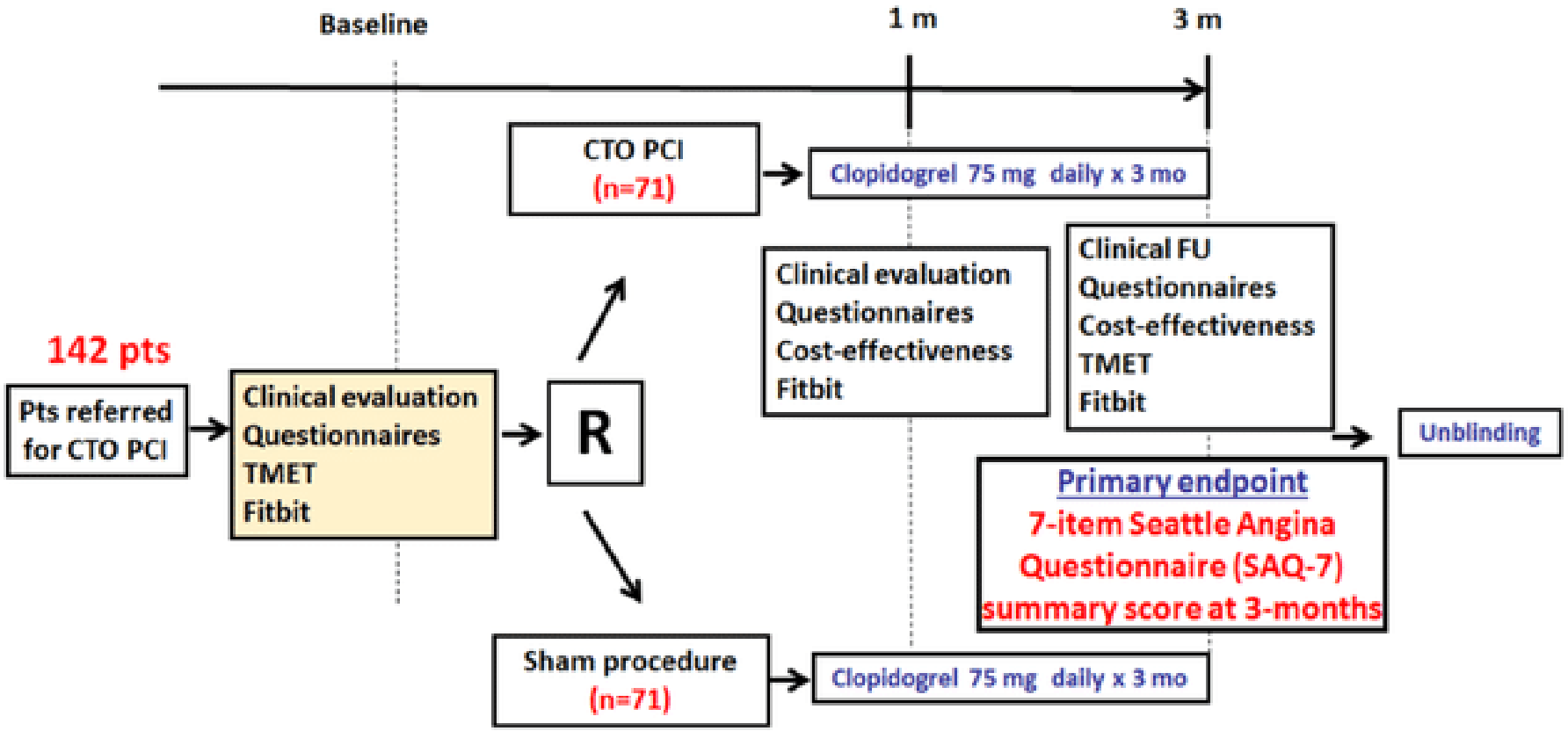




SHINE-CTO

SHam-controlled INtErvention to improve QOL in CTOs

15 sites in the US, Europe, and Russia



Indications for opening CTOs

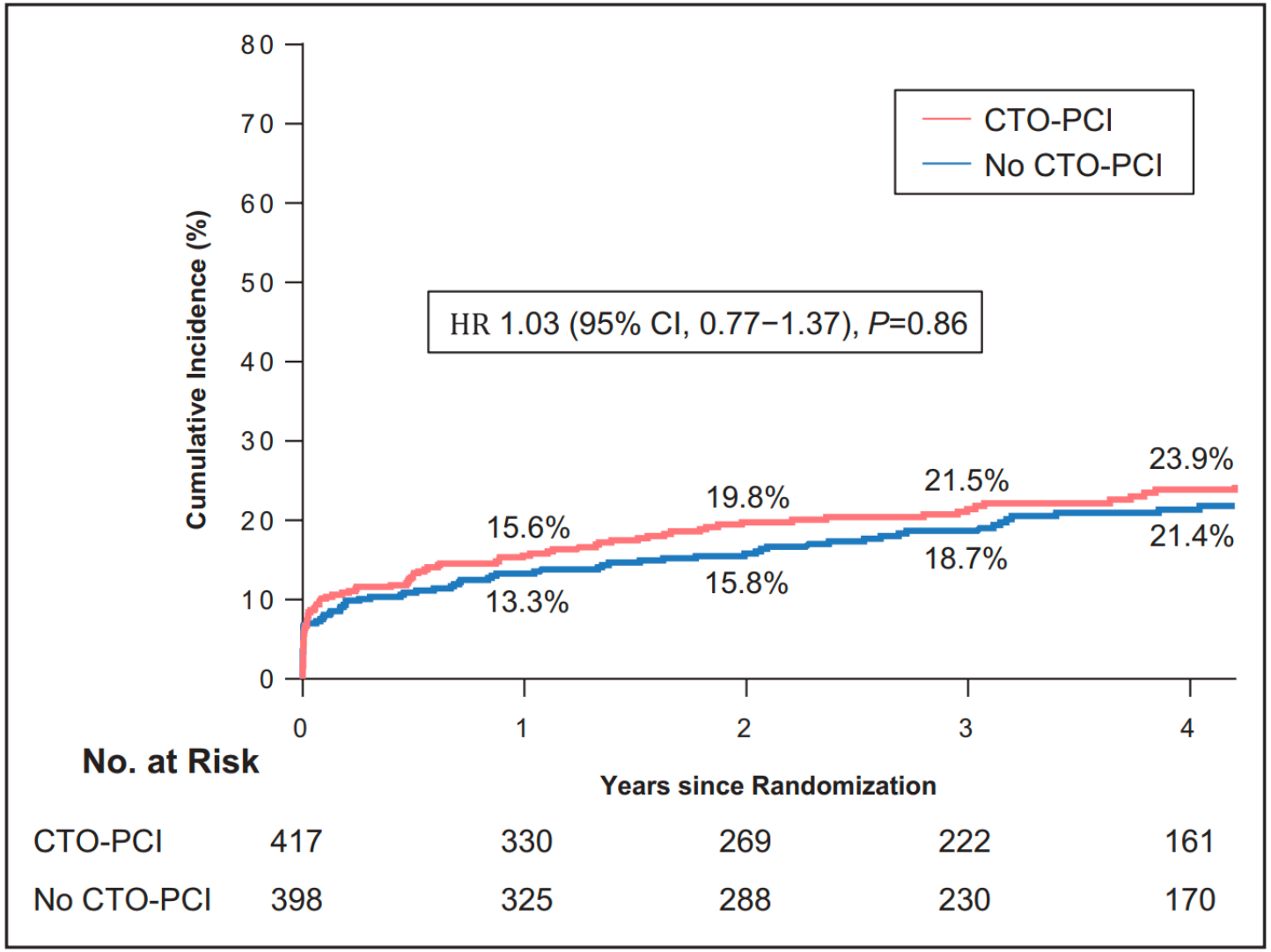
- Improving symptoms and quality of life
- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

- Improving symptoms and quality of life

• Reducing mortality or myocardial infarction

DECISION-CTO Trial

- Improving tolerance to future myocardial infarctions
- Improving left ventricular function



ORIGINAL RESEARCH ARTICLE

Randomized Trial Evaluating Percutaneous Coronary Intervention for the Treatment of Chronic Total Occlusion

The DECISION-CTO Trial

Figure 2. Cumulative incidence of the primary end point in the intention-to-treat population.
CTO indicates chronic total occlusion; HR, hazard ratio; and PCI, percutaneous coronary intervention.

Lee SW, Lee PH, Ahn JM, et al. Randomized Trial Evaluating Percutaneous Coronary Intervention for the Treatment of Chronic Total Occlusion. *Circulation*. 2019;139(14):1674-1683.

- Improving symptoms and quality of life
- **Reducing mortality or myocardial infarction**
- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

DECISION-CTO Trial

ORIGINAL RESEARCH ARTICLE

Randomized Trial Evaluating Percutaneous Coronary Intervention for the Treatment of Chronic Total Occlusion

The DECISION-CTO Trial

- The study was stopped prematurely after recruiting only 417 (planned 1200) patients to undergo PCI of all lesions including a CTO and 398 patients to PCI of nonCTO lesions only, which limits the power of the analyses.
- There were also high crossover rates from medical therapy to PCI
- The long-term mortality was 1.9% with complete revascularization vs. 3.6% with nonCTO PCI only, a non-significant 47% relative risk reduction, similar to the magnitude observed in the latest meta-analysis of observational studies.

Lee SW, Lee PH, Ahn JM, et al. Randomized Trial Evaluating Percutaneous Coronary Intervention for the Treatment of Chronic Total Occlusion. *Circulation*. 2019;139(14):1674-1683.

- Improving symptoms and quality of life
- **Reducing mortality or myocardial infarction**
- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

Meta-Analysis of Clinical Outcomes of Patients Who Underwent Percutaneous Coronary Interventions for Chronic Total Occlusions

Georgios E. Christakopoulos, MD[a], Georgios Christopoulos, MD[a], Mauro Carlino, MD[b], Omar M. Jeroudi, MD[a], Michele Roesle, RN, BSN[a], Bavana V. Rangan, BDS, MPH[a], Shuaib Abdullah, MD[a], Jerrold Grodin, MD[a], Dharam J. Kumbhani, MD, SM, MRCP[a], Minh Vo, MD[c], Michael Luna, MD[a], Khaldoon Alaswad, MD[d], Dimitri Karmpaliotis, MD[e], Stephane Rinfret, MD[f], Santiago Garcia, MD[g], Subhash Banerjee, MD[a], and Emmanouil S. Brilakis, MD, PhD[a,*]

Successful percutaneous coronary intervention (PCI) for chronic total occlusions (CTOs) has been associated with clinical benefit. There are no randomized controlled trials on long-term clinical outcomes after CTO PCI, limiting the available evidence to observational cohort studies. We sought to perform a weighted meta-analysis of the long-term outcomes of successful versus failed CTO PCI. A total of 25 studies, published from 1990 to 2014, with 28,486 patients (29,315 CTO PCI procedures) were included. We analyzed data on mortality, subsequent coronary artery bypass grafting (CABG), myocardial infarction, major adverse cardiac events, angina pectoris, stroke, and target vessel revascularization using random-effects models. Procedural success was 71% (range 51% to 87%). During a weighted mean follow-up of 3.11 years, compared with unsuccessful, successful CTO PCI was associated with lower mortality (odds ratio [OR] 0.52, 95% confidence interval [CI] 0.43 to 0.63), less residual angina (OR 0.38, 95% CI 0.24 to 0.60), lower risk for stroke (OR 0.72, 95% CI 0.60 to 0.88), less need for subsequent coronary artery bypass grafting (OR 0.18, 95% CI 0.14 to 0.22), and lower risk for major adverse cardiac events (0.59, 95% CI 0.44 to 0.79). There was no difference in the incidence of target vessel revascularization (OR 0.66, 95% CI 0.36 to 1.23) or myocardial infarction (OR 0.73, 95% CI 0.52 to 1.03). Outcomes were similar in patients who underwent balloon angioplasty only or stenting with bare metal or drug-eluting stents. Compared with failed procedures, successful CTO PCIs are associated with a lower risk of death, stroke, and coronary artery bypass grafting and less recurrent angina pectoris. Published by Elsevier Inc. (Am J Cardiol 2015;115:1367–1375)

Christakopoulos GE, Christopoulos G, Carlino M, et al. Meta-analysis of clinical outcomes of patients who underwent percutaneous coronary interventions for chronic total occlusions. Am J Cardiol. 2015;115(10):1367-75

- Improving symptoms and quality of life

• Reducing mortality or myocardial infarction

- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

All-cause mortality

Study	PCI success Events	Total	PCI failure Events	Total	Weight	Odds ratio [95%CI]
Finci	5	100	3	100	0.29	1.70 [0.32, 11.23]
Warren	0	26	0	18	0	* (excluded)
Ivanhoe	3	317	7	163	0.94	0.21 [0.04, 0.95]
Angioi	3	93	9	108	0.83	0.37 [0.06, 1.54]
Noguchi	7	134	15	92	1.74	0.28 [0.09, 0.78]
Suero	395	1491	180	514	20.22	0.67 [0.54, 0.84]
Olivari	3	286	3	83	0.47	0.28 [0.04, 2.16]
Hoye	37	567	36	304	4.50	0.52 [0.31, 087]
Drozd	7	280	5	149	0.65	0.74 [0.20, 3.01]
Arslan	19	117	37	115	3.21	0.41 [0.21, 0.80]
Aziz	9	377	12	166	1.67	0.31 [0.12, 0.83]
Valenti	17	344	17	142	2.35	0.38 [0.18, 0.83]
Labriole	7	127	2	45	0.29	1.25 [0.23, 12.81]
Chen	2	132	3	20	0.53	0.09 [0.01, 0.84]
Lee	8	251	4	82	0.60	0.64 [0.17, 3.00]
Mehran	74	1226	49	565	6.48	0.68 [0.46, 1.01]
Jolicoeur	22	213	24	133	2.72	0.52 [0.27, 1.03]
Yang	7	87	10	49	1.01	0.34 [0.10, 1.09]
Borgia	19	237	9	65	1.34	0.54 [0.22, 1.44]
Jones	26	582	44	254	6.01	0.22 [0.13, 0.38]
George S	492	10199	259	4240	35.78	0,78 [0.67, 0.91]
Yamamoto	92	1192	35	332	5.19	0.71 [0.47, 1.10]
Kim	56	2045	20	523	3.18	0.71 [0.41, 1.26]
TOTAL	**1310**	**20423**	**783**	**8262**	**100.00**	**0.52 [0.43, 0.63]**

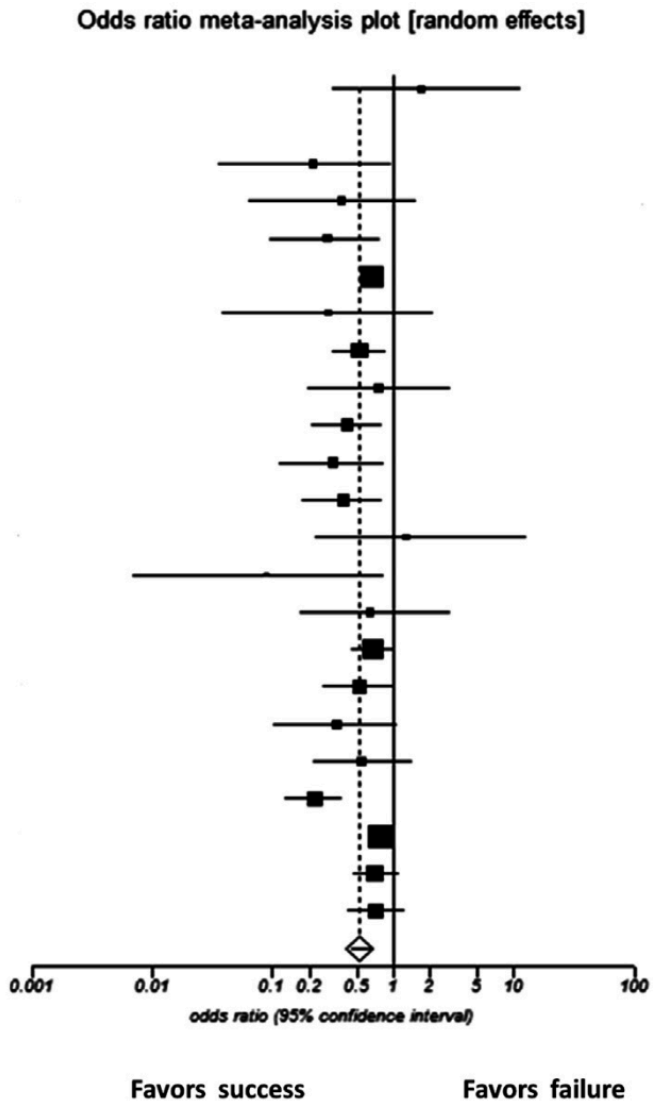


Figure 2. Forest plot for long-term all-cause mortality with successful versus failed CTO PCI.

Christakopoulos GE, Christopoulos G, Carlino M, et al. Meta-analysis of clinical outcomes of patients who underwent percutaneous coronary interventions for chronic total occlusions. Am J Cardiol. 2015;115(10):1367-75

- Improving symptoms and quality of life

• Reducing mortality or myocardial infarction

- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

MACE

Study	PCI success Events	Total	PCI failure Events	Total	Weight%	Odds ratio [95%CI]
Finci	33	100	41	100	3.36	0.71 [0.38, 1.31]
Warren	3	26	7	18	0.90	0.20 [0.03, 1.15]
Ivanhoe	63	317	76	158	9.94	0.27 [0.17, 0.41]
Angioi	43	93	45	108	2.74	1.20 [0.66, 2.19]
Noguchi	67	134	46	92	3.34	1.00 [0.57, 1.76]
Olivari	35	286	21	83	3.50	0.41 [0.22, 0.80]
Hoye	206	567	177	304	17.95	0.41 [0.30, 0.55]
Drozd	71	280	43	149	5.12	0.84 [0.53, 1.34]
Arslan	55	117	60	115	3.92	0.81 [0.47, 1.41]
Valenti	70	344	30	142	4.14	0.95 [0.58, 1.60]
Labriole	29	127	2	45	0.28	6.36 [1.48, 57.01]
Chen	19	132	7	20	1.27	0.31 [0.10, 1.06]
Lee	24	251	6	82	1.00	1.34 [0.51, 4.16]
Mehran	147	1226	137	565	20.19	0.43 [0.33, 0.56]
Jolicoeur	75	213	69	133	6.73	0.50 [0.32, 0.80]
Yang	19	87	19	49	2.32	0.44 [0.19, 1.02]
Borgia	35	237	28	62	4.63	0.21 [0.11, 0.41]
Niccoli	17	196	32	121	4.42	0.26 [0.13, 0.52]
Ciercwiez	21	138	41	138	4.25	0.42 [0.22, 0.79]
TOTAL	1032	4871	887	2484	100	0.55 [0.43, 0.71]

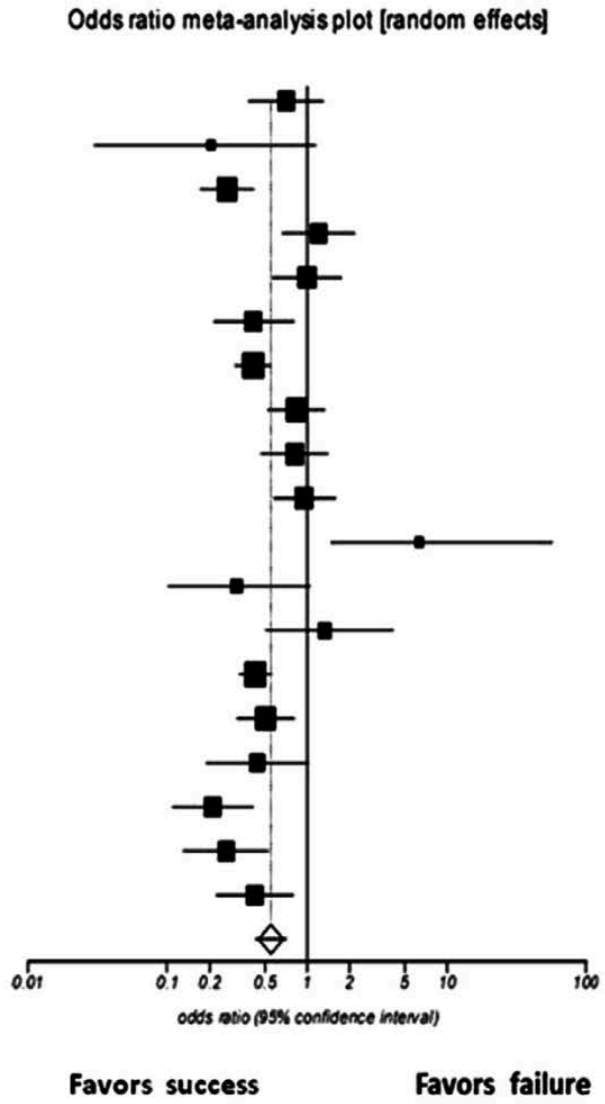


Figure 4. Forest plot for long-term MACE with successful versus failed CTO PCI.

Christakopoulos GE, Christopoulos G, Carlino M, et al. Meta-analysis of clinical outcomes of patients who underwent percutaneous coronary interventions for chronic total occlusions. Am J Cardiol. 2015;115(10):1367-75

- Improving symptoms and quality of life

• Reducing mortality or myocardial infarction

- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

Angina pectoris

Study	PCI success Events	Total	PCI failure Events	Total	Weight%	Odds ratio [95%CI]
Finci	43	100	74	100	c	0.27 [0.14, 0.50]
Warren	3	26	7	18	2.13	0.20 [0.03, 1.15]
Ivanhoe	90	286	53	144	14.09	0.79 [0.51, 1.23]
Angioi	27	93	56	108	10.72	0.34 [0.18, 0.64]
Olivari	28	248	15	60	6.25	0.38 [0.18, 0.84]
Drozd	120	280	79	149	17.19	0.66 [0.44, 1.01]
Jolicoeur	21	213	14	133	4.53	0.93 [0.43, 2.06]
Borgia	38	237	30	65	11.54	3.53 [1.87, 6.61]
Ciercwierz	44	138	107	138	21.25	0.13 [0.07, 0.23]
TOTAL	**414**	**1621**	**435**	**915**	**100**	**0.38 [0.24, 0.60]**

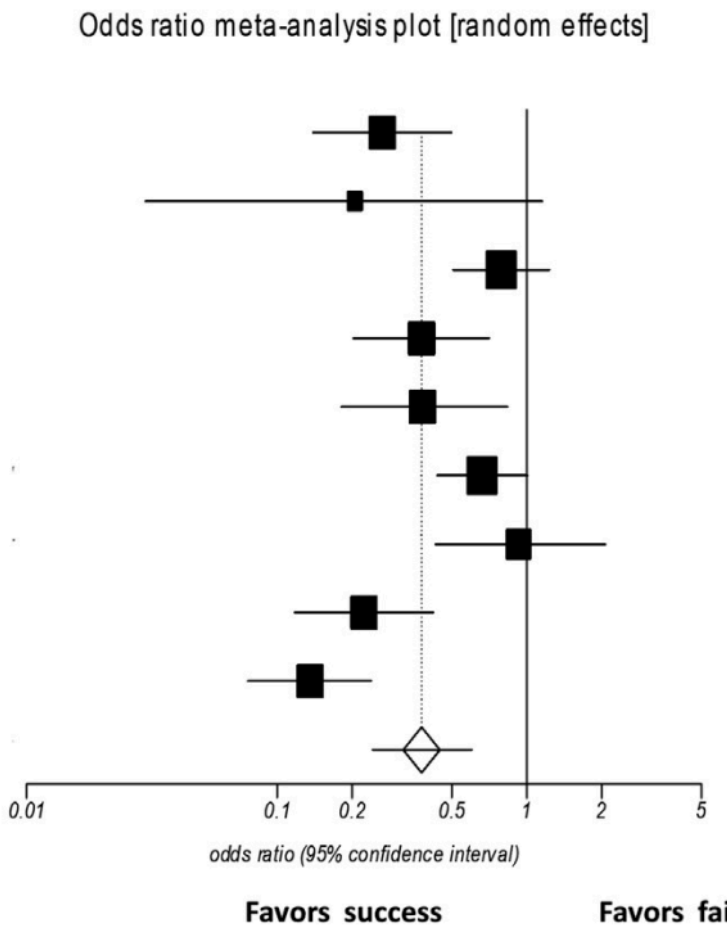


Figure 5. Forest plot for angina with successful versus failed CTO PCI.

Christakopoulos GE, Christopoulos G, Carlino M, et al. Meta-analysis of clinical outcomes of patients who underwent percutaneous coronary interventions for chronic total occlusions. Am J Cardiol. 2015;115(10):1367-75

Indications for opening CTOs

- Improving symptoms and quality of life
- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

- Improving symptoms and quality of life
- Reducing mortality or myocardial infarction

• Improving tolerance to future myocardial infarctions

- Improving left ventricular function

Miocardial infarction

Study	PCI success Events	PCI success Total	PCI failure Events	PCI failure Total	Weight%	Odds ratio [95%CI]
Warren	0	26	0	18	0	* (excluded)
Ivanhoe	19	317	11	158	7.16	0.85 [0.37, 2.04]
Angioi	3	93	2	108	0.93	1.77 [0.20, 21.52]
Olivari	2	286	3	83	2.40	0.19 [0.02, 1.68]
Hoye	59	567	51	304	30.88	0.58 [0.38, 0.88]
Drozd	10	280	4	149	2.61	1.34 [0.38, 5.96]
Arslan	38	117	27	115	9.54	1.57 [0.85, 2.93]
Valenti	3	344	0	142	0.36	2.92 [0.17, infinity]
Labriole	0	127	0	40	0	* (excluded)
Chen	4	132	3	20	2.62	0.18 [0.03, 1.34]
Lee	3	251	1	82	0.77	0.98 [0.08, 52.0]
Mehran	71	1226	30	565	20.08	1.10 [0.70, 1.76]
Jolicoeur	8	213	4	133	2.46	1.26 [0.33, 5.82]
Yang	1	87	0	49	0.33	1.72 [0.01, infinity]
Borgia	8	237	9	65	7.09	0.22 [0.07, 0.67]
Niccoli	2	196	5	121	3.18	0.24 [0.02, 1.50]
Yamamoto	30	1192	15	332	7.12	0.43 [0.23, 0.81]
Kim	9	2045	3	523	2.47	0.77 [0.19, 4.42]
TOTAL	**270**	**7736**	**168**	**3007**	**100**	**0.73 [0.52, 1.03]**

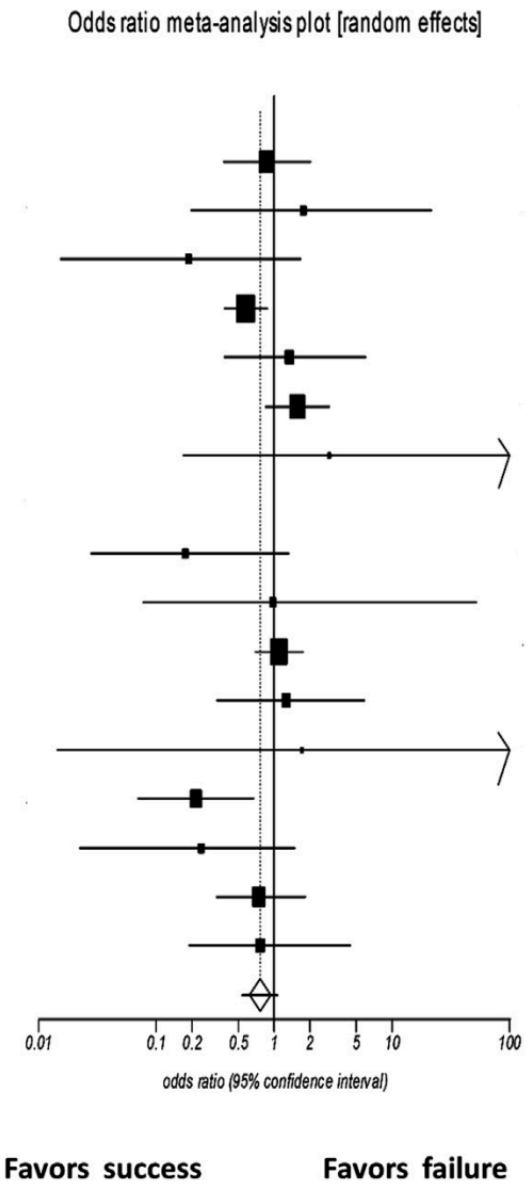


Figure 3. Forest plot for MI with successful versus failed CTO PCI.

Christakopoulos GE, Christopoulos G, Carlino M, et al. Meta-analysis of clinical outcomes of patients who underwent percutaneous coronary interventions for chronic total occlusions. Am J Cardiol. 2015;115(10):1367-75

Indications for opening CTOs

- Improving symptoms and quality of life
- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions
- Improving left ventricular function

- Improving symptoms and quality of life
- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions

• Improving left ventricular function

Explore Trial

openheart

Impact of collateralisation to a concomitant chronic total occlusion in patients with ST-elevation myocardial infarction: a subanalysis of the EXPLORE randomised controlled trial

Table 5 Event rates at long-term follow-up

	GOODCOLL (n=162)	POORCOLL (n=140)	P values
All-cause death	8 (5%)	13 (9%)	0.174
Composite MACE	16 (10%)	20 (14%)	0.286
Cardiac death	4 (3%)	5 (4%)	0.738
All MI	9 (6%)	16 (11%)	0.092
CABG	4 (3%)	4 (3%)	1.000

van Dongen IM, Elias J, van Houwelingen KG, et al. Impact of collateralisation to a concomitant chronic total occlusion in patients with ST-elevation myocardial infarction: a subanalysis of the EXPLORE randomised controlled trial. *Open Heart*. 2018;5(2):e000810. Published 2018 Jul 16.

- Improving symptoms and quality of life
- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions

• Improving left ventricular function

Explore Trial

openheart

Impact of collateralisation to a concomitant chronic total occlusion in patients with ST-elevation myocardial infarction: a subanalysis of the EXPLORE randomised controlled trial

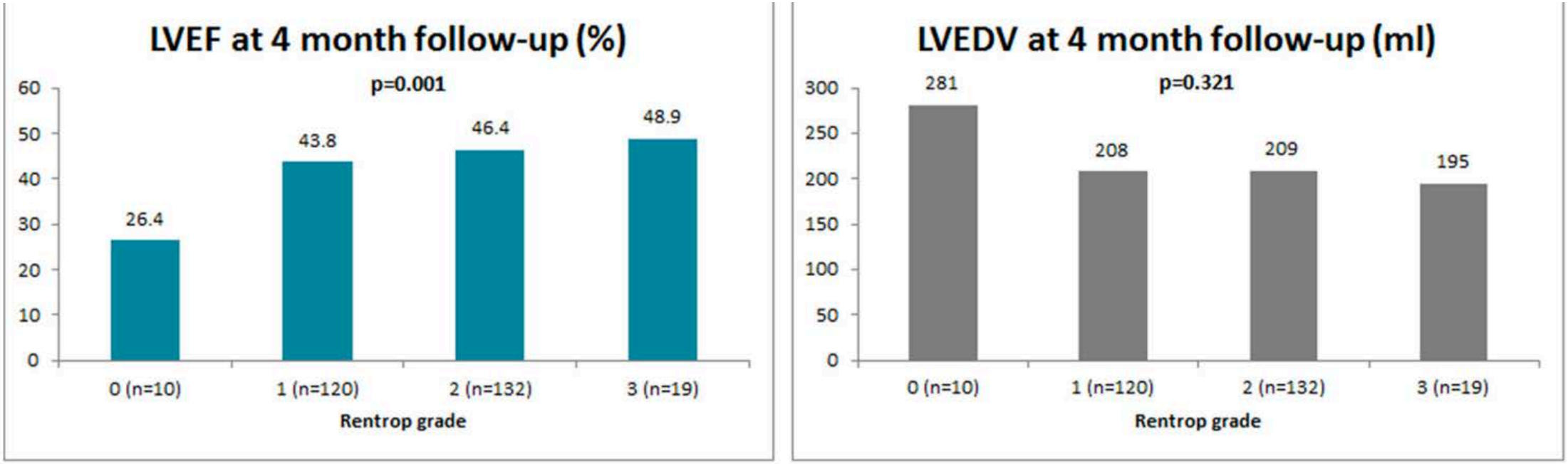


Figure 2 The impact of Rentrop grade collaterals to the coronary chronic total occlusion on left ventricular ejection fraction (LVEF) and left ventricular end-diastolic volume (LVEDV).

van Dongen IM, Elias J, van Houwelingen KG, et al. Impact of collateralisation to a concomitant chronic total occlusion in patients with ST-elevation myocardial infarction: a subanalysis of the EXPLORE randomised controlled trial. *Open Heart*. 2018;5(2):e000810. Published 2018 Jul 16.

- Improving symptoms and quality of life
- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions

• Improving left ventricular function

Explore Trial

- ✓ This study was assessing only ventricular remodelling in patients presenting with a STEMI with concurrent CTO, and hence does not reflect the majority of patients considered for CTO PC

- ✓ While no difference in the primary endpoint was observed, those with well-developed collaterals supplying the CTO territory (Rentropgrades 2-3) had significantly higher LVEF at 4 months (46.2±11.4% vs. 42.1±12.7%, p=0.004).

- ✓ Residual ischemia or viability in the CTO territory was not assessed prior to CTO PC

- Improving symptoms and quality of life
- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions

• Improving left ventricular function

Explore Trial

✓ Furthermore, the success rate of this study was relatively low, particularly compared to the other randomised trials published in the last few years, which may reflect eithermore complex disease, or recruitment in less experienced centres.

- Improving symptoms and quality of life
- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions

Improving left ventricular function

CTO specific studies, as well as general stable coronary disease studies, suggest that there is a survival benefit with revascularisation when the ischaemic territory is greater than 12.5% of at risk myocardium. It is thus unsurprising that the mortality benefit appears to be particularly related to PCI of the LAD, rather than the RCA

- Safley DM, Koshy S, Grantham JA, Bybee KA, House JA, Kennedy KF, et al. Changes in myocardial ischemic burden following percutaneous coronary intervention of chronic total occlusions. Catheter Cardiovasc Interv 2011;78(3):337–43.

- Claessen BE, Dangas GD, Godino C, Henriques JP, Leon MB, Park SJ, et al. Impact of target vessel on long-term survival after percutaneous coronary intervention for chronic total occlusions. Catheter Cardiovasc Interv 2013;82(1):76–82.

- Improving symptoms and quality of life
- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions

• Improving left ventricular function

Patients were stratified by their initial MPI summed difference score (SDS)

1. SDS <4—normal/minimal ischemia (<5% of ischemic myocardium);
2. SDS 4–8—mild ischemia (5– 9.9%);
3. SDS 9–13—moderate ischemia (10–16%);
4. SDS >13—severe ischemia (>16%)

Changes in Myocardial Ischemic Burden Following Percutaneous Coronary Intervention of Chronic Total Occlusions

David M. Safley,[1,2*] MD, Sindhu Koshy,[1] MD, J. Aaron Grantham,[1,2] MD, Kevin A. Bybee,[1,2] MD, John A. House,[1] MS, Kevin F. Kennedy,[1] MS, and Barry D. Rutherford,[1,2] MD

Objectives: We assessed the potential for percutaneous coronary intervention (PCI) of a chronic total occlusion (CTO) to decrease myocardial ischemia and established objective criteria to predict post-procedure improvement. Background: Optimal treatment for CTO of coronary arteries is controversial, and selection criteria for PCI of CTO are subjective. Methods: All patients undergoing CTO PCI at a single center between 2002 and 2007 were included if myocardial perfusion imaging (MPI) was performed within 12 ± 3 months before and a follow-up study within 12 ± 3 months after PCI. Average summed difference scores were calculated and converted to percent ischemic myocardium to classify patients as having normal/minimal, mild, moderate, or severe ischemia. A significant improvement in ischemia following PCI was classified as an absolute ≥5% decrease in ischemic myocardium. Receiver operating characteristic (ROC) curves were used to identify ischemic thresholds predictive of decreased and increased ischemic burden on follow-up MPI. Results: In 301 patients, average baseline ischemic burden was 13.1% ± 11.9% and decreased to 6.9% ± 6.5% ($P < 0.001$) during follow-up. Overall, 53.5% of patients met criteria for improvement following PCI. These patients were more likely to be male, without diabetes, with CTO in the left anterior descending artery, and classified as having high ischemic burden at baseline. ROC analysis identified a baseline 12.5% ischemic burden as optimal in identifying those most likely to have a significantly decreased ischemic burden post-PCI. Those with a baseline ischemic burden less than 6.25% were more likely to have an increased ischemic burden post-PCI. Conclusions: Ischemic burden is reduced following CTO PCI, and the decrease is greater at high ischemic burden. A threshold of 12.5% ischemic burden is suggested as a criterion for performing PCI in the setting of CTO.

Safley DM, Koshy S, Grantham JA, et al. Changes in myocardial ischemic burden following percutaneous coronary intervention of chronic total occlusions. *Catheter Cardiovasc Interv*. 2011;78(3):337-343.

- Improving symptoms and quality of life
- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions

• Improving left ventricular function

NO ISHEMIA = HARM!

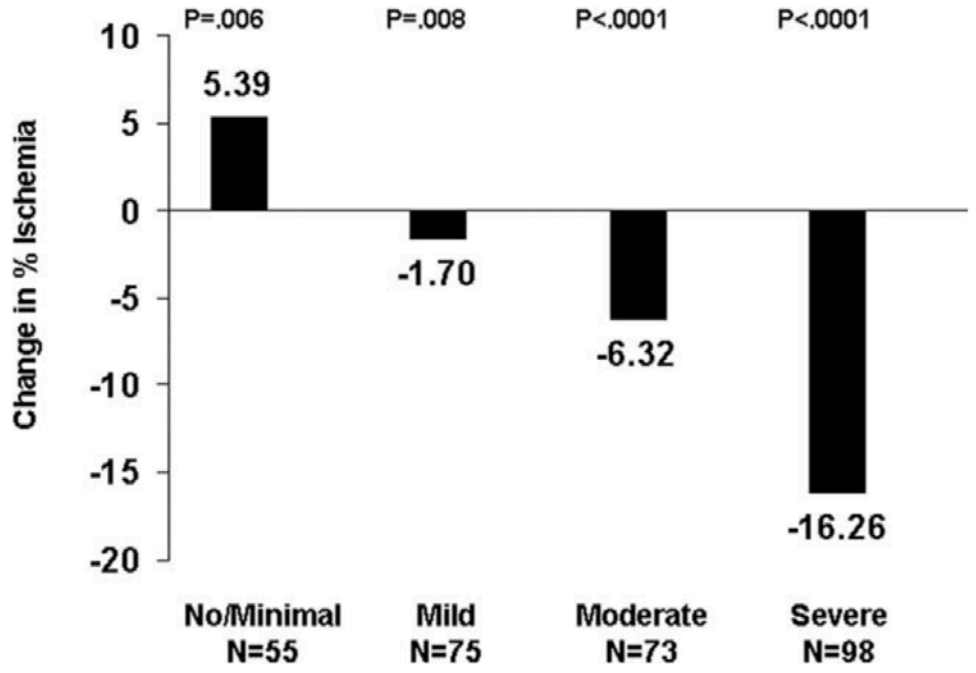
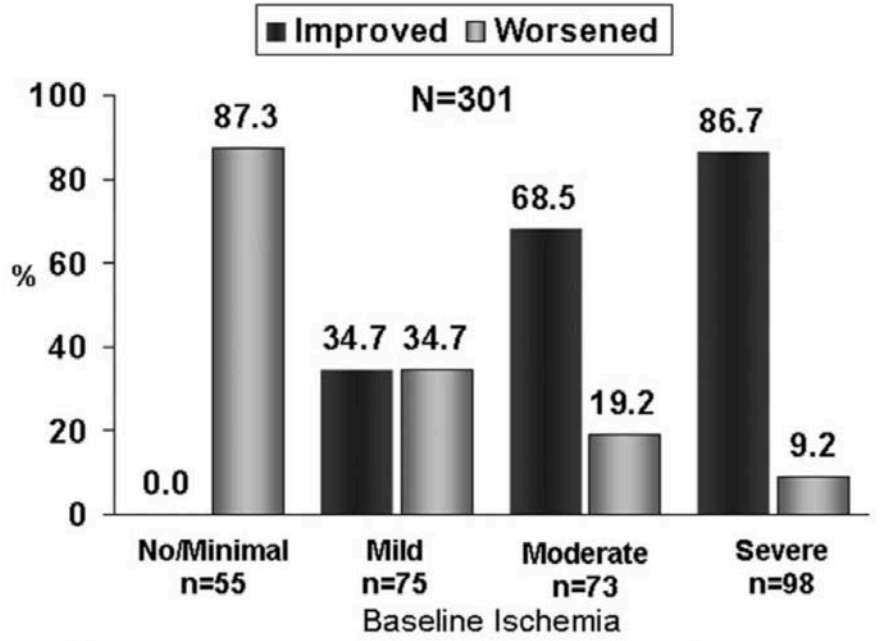


Fig. 1. Change in sum difference scores by severity of baseline ischemia assessed by myocardial perfusion imaging performed 12 months before and after percutaneous coronary intervention for chronic total occlusion.



P<0.001 for the trend of more improvement with greater ischemia at baseline

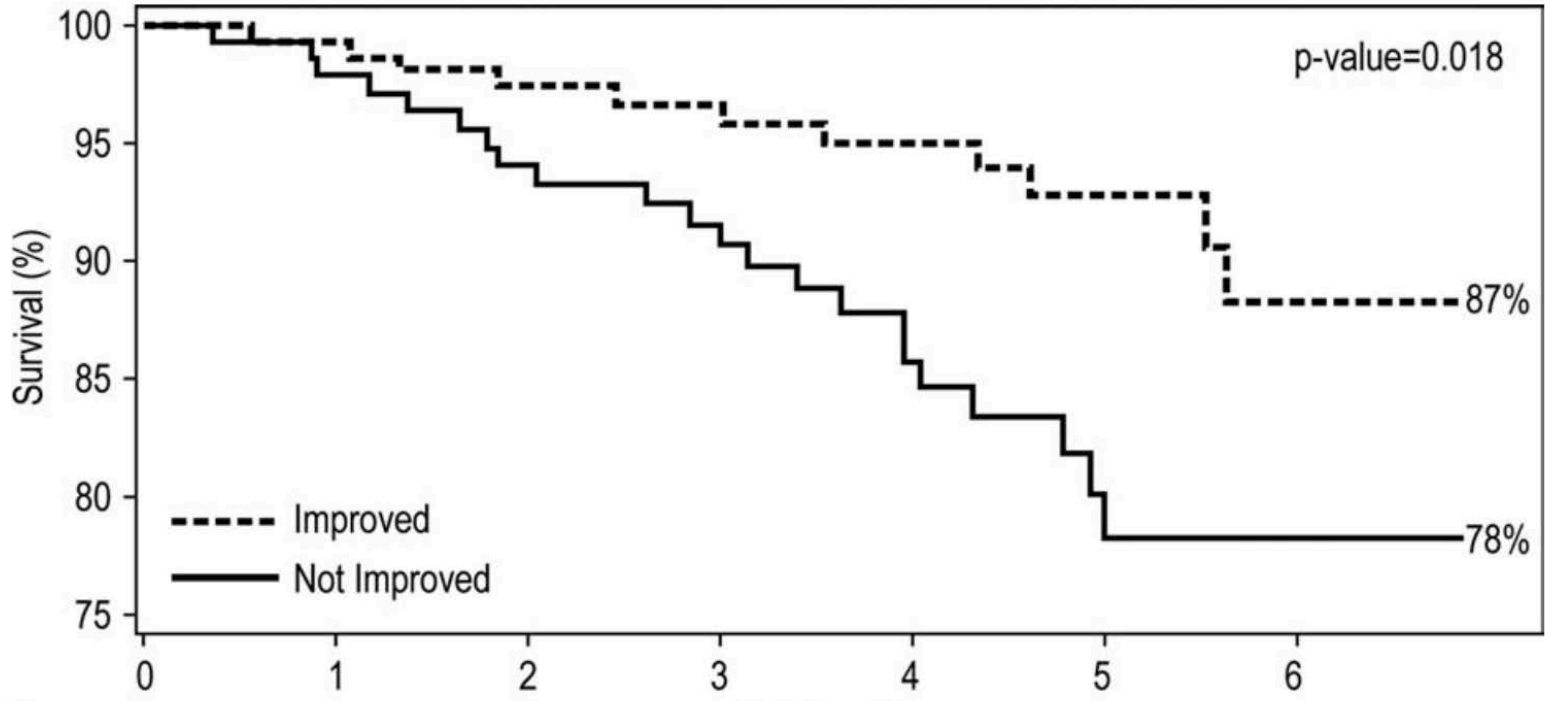
P<0.001 for the trend of more decrease with less ischemia at baseline

Fig. 2. Percentage of patients with changes of ≥5% in ischemic myocardium after percutaneous coronary intervention for chronic total occlusion stratified by baseline ischemia.

Safley DM, Koshy S, Grantham JA, et al. Changes in myocardial ischemic burden following percutaneous coronary intervention of chronic total occlusions. *Catheter Cardiovasc Interv*. 2011;78(3):337-343.

- Improving symptoms and quality of life
- Reducing mortality or myocardial infarction
- Improving tolerance to future myocardial infarctions

• Improving left ventricular function



No. at risk							
Improved	161	159	148	134	120	85	42
Not Improved	140	136	124	111	89	62	30

Fig. 3. Kaplan–Meier survival in patients with vs. without improvement in ischemia on myocardial perfusion imaging.

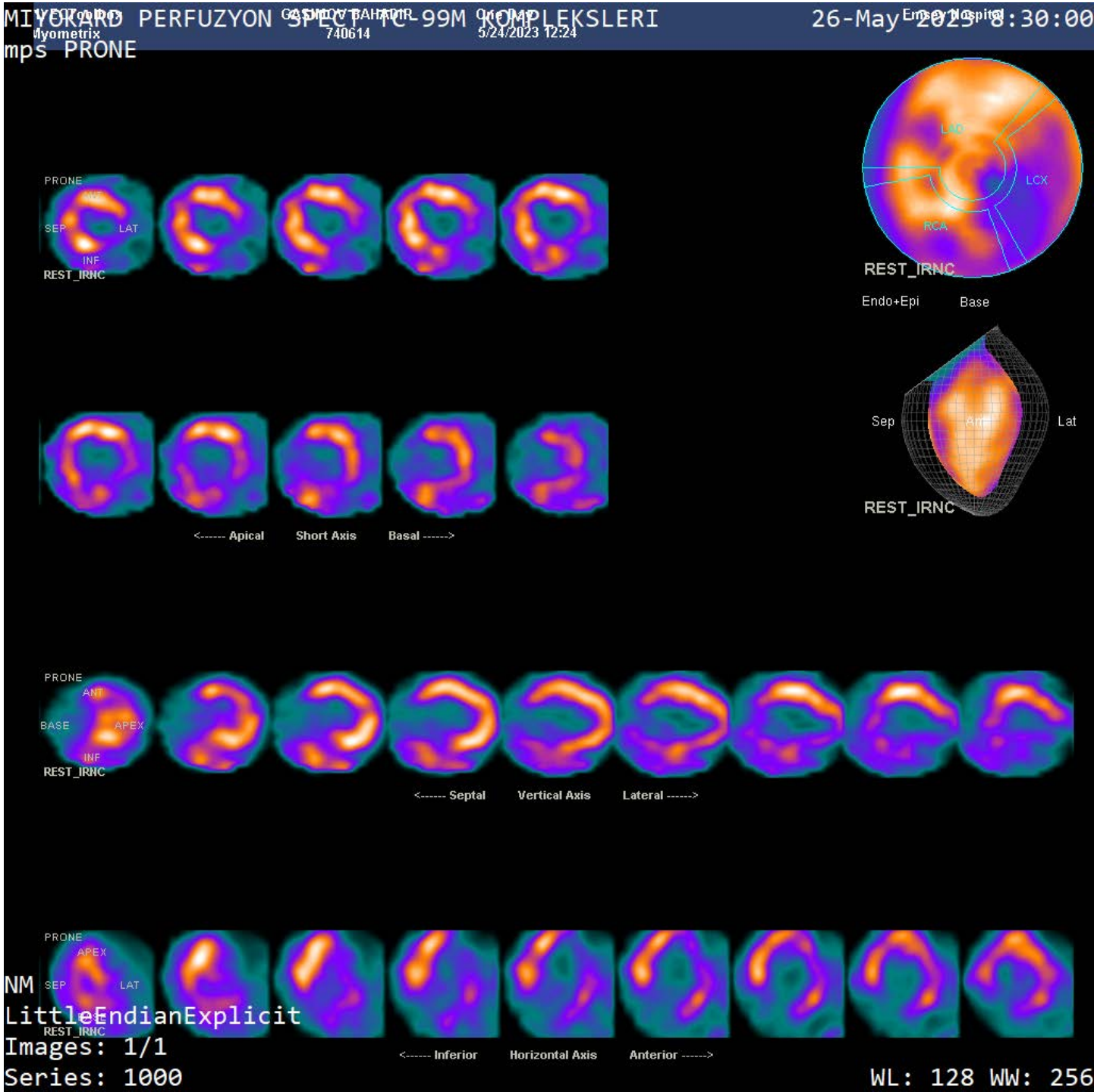
Safley DM, Koshy S, Grantham JA, et al. Changes in myocardial ischemic burden following percutaneous coronary intervention of chronic total occlusions. *Catheter Cardiovasc Interv*. 2011;78(3):337-343.

What should be the next step?

- CX – RCA PCI?
- OMT?

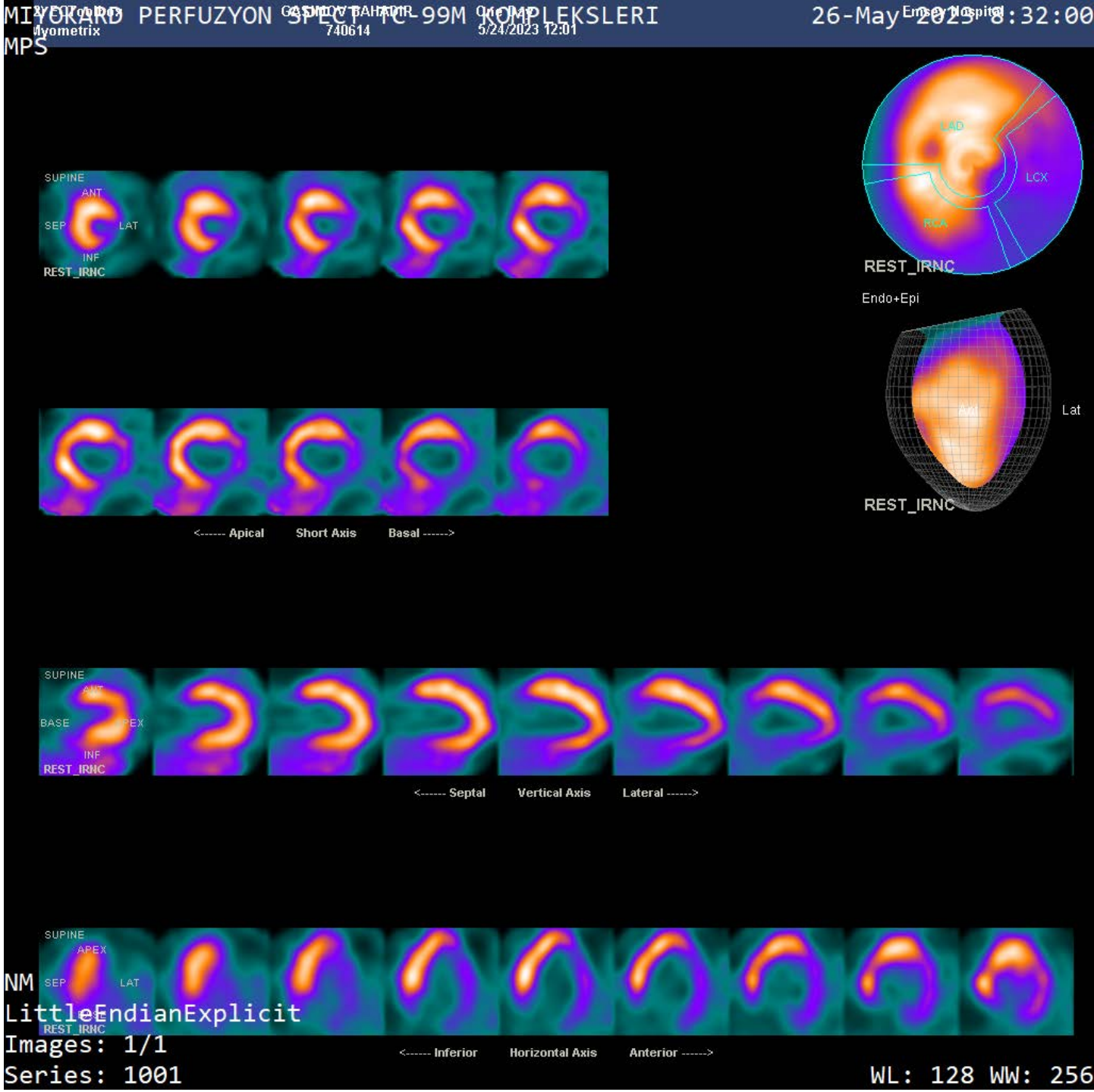
2023 SPECT

Apical infero-lateral wall nonviable
Other segments viable

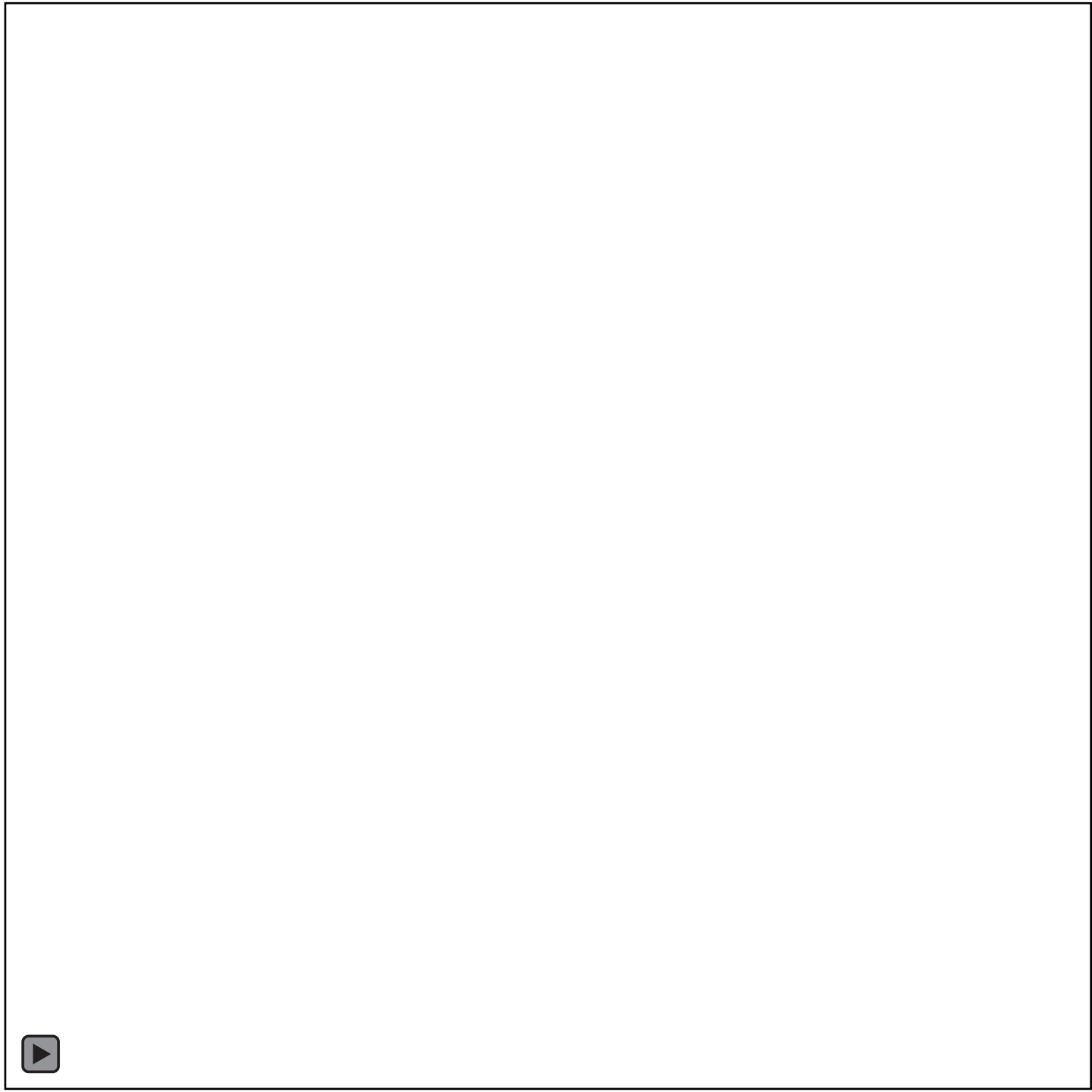


2023 SPECT

Apical infero-lateral wall nonviable
Other segments viable



2023 CX PCI



Take Home Message

- Neither ISHEMIA nor other CTO-centric RCTs shows death and MI benefit in stable IHD.
- LAD CTO PCI shows more improvement in LVEF compared with OMT alone.
- There is a survival benefit with revascularisation when the ischaemic territory is greater than 12.5% of at risk myocardium
- With evident myocardial viability by MPI and CMR revascularization was associated with lower mortality
- Patients with good collaterals (Rentrop grade 2-3) had significantly higher LVEF and shows benefit in survey


thank you
merci
danke
謝謝
gracias
teşekkür ederim
ngiyabonga
dank je
obrigado
dziękuję
bedankt
go raibh maith agat
kop khun krap
sukriya
terima kasih
grazie
arigatô
dakujem
takk
tapadh leat
mochchakkeram
mauruuru
hvala
sagolun
tack
merci
спасибо
рахмат
Баярлалаа
faafetai lava
kiitos
dankie
vinaka
blagodaram
спасибі
misaotra
matondo
paldies
grazzi
mahalo
хвала
asante
manana
obrigada
murakoze
tenki
chokrane
mamnun
дякую
djiere dieuf
tau
enkosi
bayarlalaa
gràçie
köszönöm
nanni
nandri
dhanyavad
akun
dankon
aĉiŭ
chnorakaloutioun
gratias ago
grâcies
sulpáy
taiku
sobodi
dèkuji
mèsi
didi madloba
najis tuke
kam sah hamnida
rahmat
ありがとう
tanemirt
rahmet
diolch
dhanyavadagalu
shukriya
merci
мерси
trugarez
ευχαριστώ
xièxie
감사합니다
তোমাকে ধন্যবাদ