ULTRA-LOW CONTRAST PCI: BASICS AND ROLE OF ADJUNCTIVE MODALITIES

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ARCH ELITE Fellows' Program

November 19, 2021

- No Conflicts

PCI today

Training

- Should we do it?
- How do we do it?

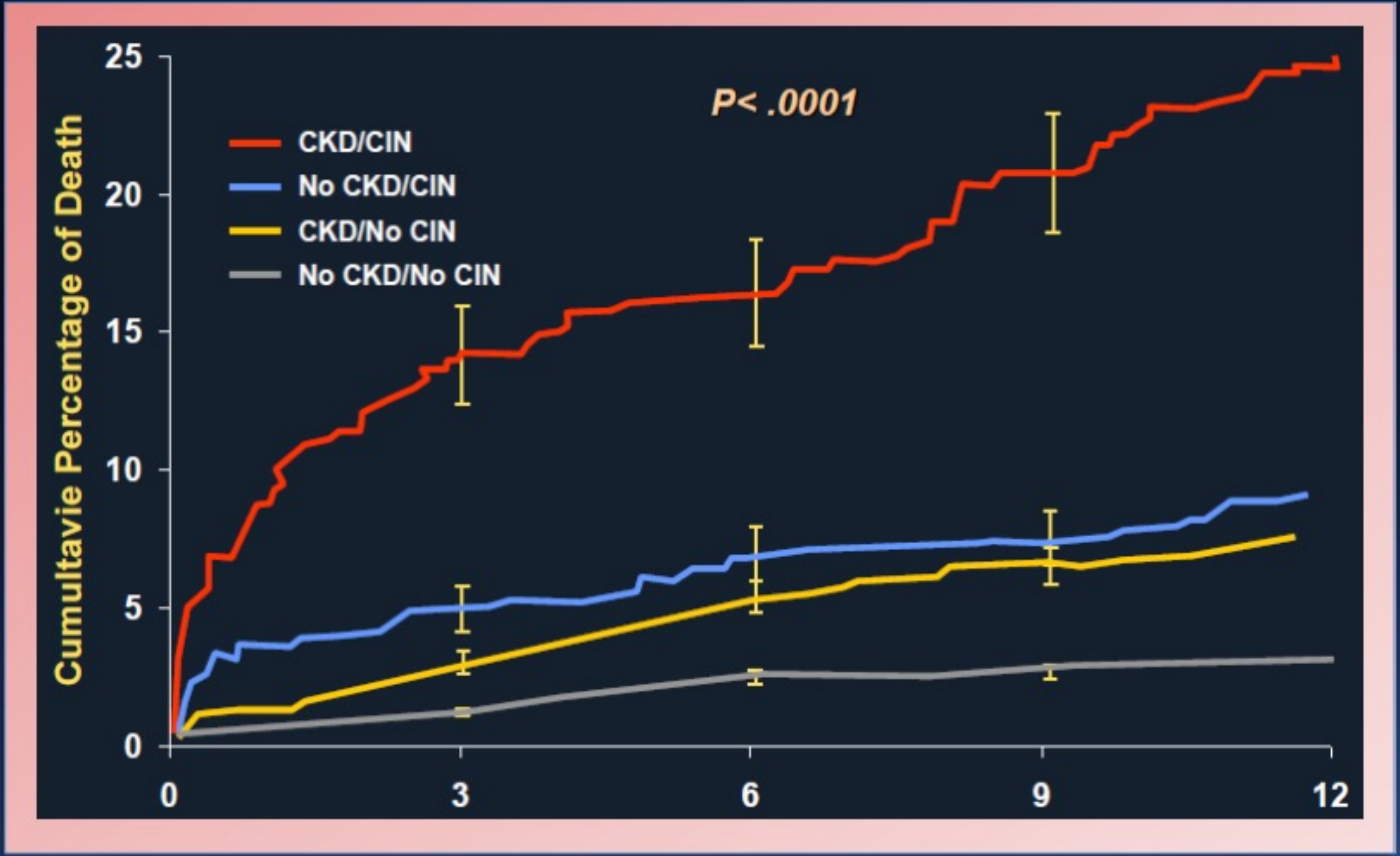
"Real World" PCI

- Appropriate Use
- Quality and Safety
  - AKI
  - Bleeding
  - Mortality

Contrast-Induced Nephropathy

- Definition
  - 48-72 h after administration of contrast
  - Increase in serum creatinine of more than 0.5 or increase of at least 25% from baseline level
  - Intra-arterial versus intravenous contrast administration

Morbidity of Contrast Nephropathy



Dangas et al. 2005

CAD and CKD

- Cardiovascular death accounts for OVER 50% of all deaths in patients with CKD and ESRD
- These patients are usually excluded from clinical trials
- Revascularization by PCI in patients with advanced CKD is drastically underutilized

Author	Presentation	N	CKD	CKD Invasive	No CKD Invasive
Chertow	MI	57,284	26%	25%	47%
Han	NSTEACS	45,343	14%	48%	74%
Goldenberg	NSTEACS	13,141	32%	50%	68%
Szummer	MI	57,477	33%	33%	58%

eGFR	Strategy	Adjusted OR	P
60-90	OMT vs PCI	0.63 (0.49-0.81)	<0.001
45-60	OMT vs PCI	0.69 (0.51-0.95)	0.020
30-45	OMT vs PCI	0.68 (0.49-0.94)	0.021
<30	OMT vs PCI	0.80 (0.52-1.24)	0.32

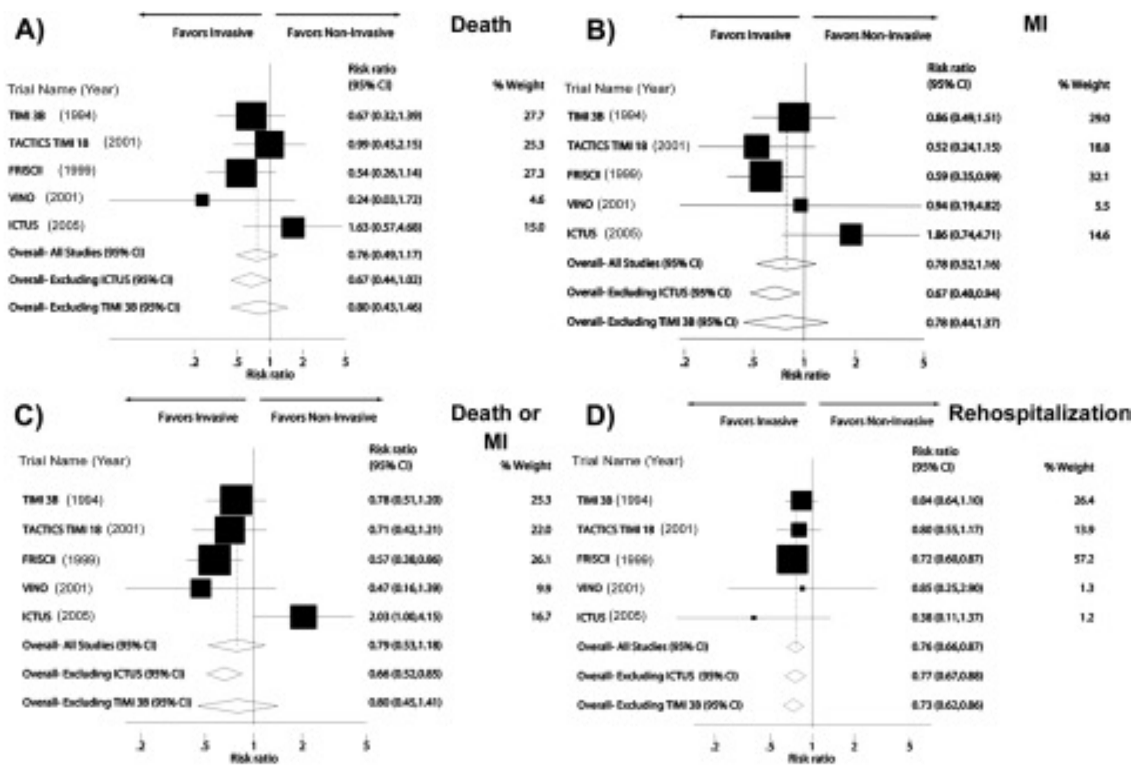
CKD and PCI

Multiple comorbidities

Delays care

Increased morbidity/mortality

Benefits of PCI in NSTEACS



DM Charytan 2009

An Invasive Strategy

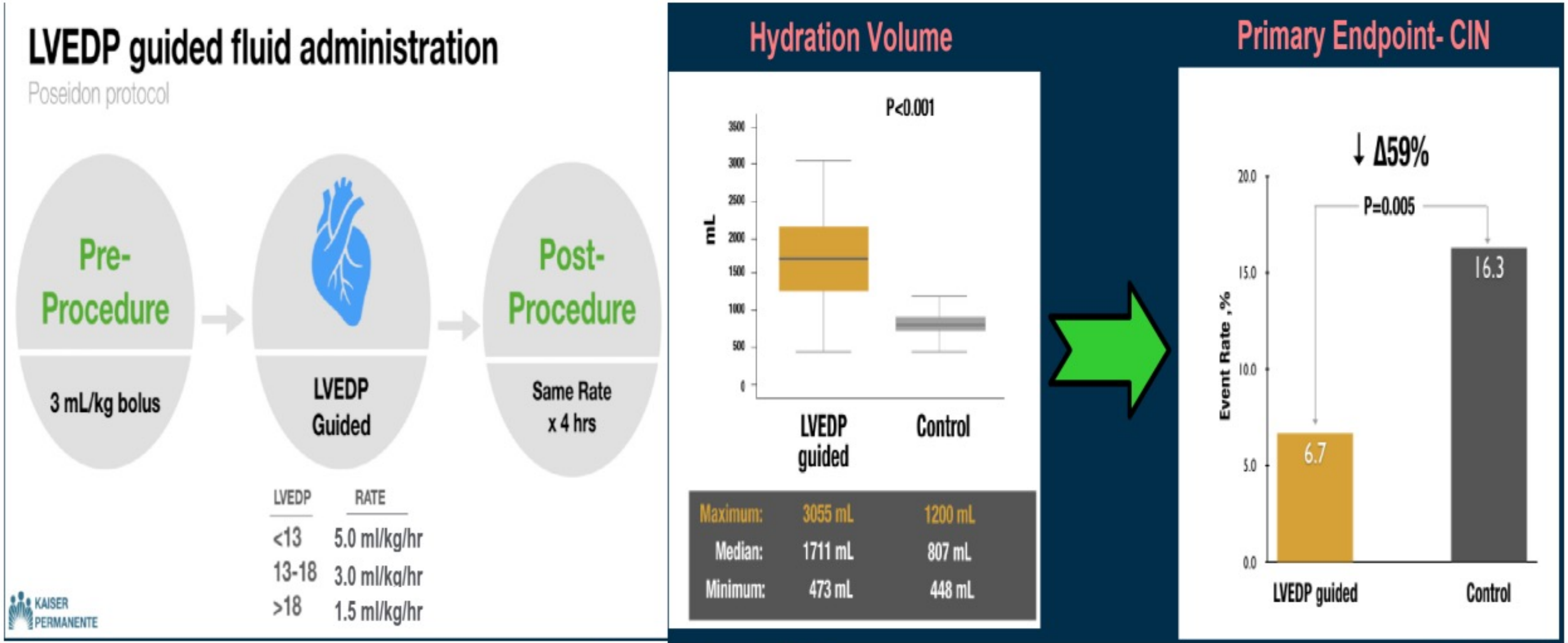
- Significantly reduced the risk for rehospitalization
- Nonsignificant reductions in the risks for death and MI
- Mortality rate was 8.0% in patients with CKD compared with only 3.1% in patients without CKD randomly assigned to conservative therapy in these trials
- The observed *relative* risk reductions likely mean substantially higher *absolute* benefits from an invasive strategy for this group of patients.
- Quantitatively, this suggests that an invasive strategy could prevent up to 20 deaths for every 1000 patients compared with only six deaths prevented in patients without CKD.

Hydration, hydration, hydration

- Know your "green zone"
  - Various calculations to determine safe amount of contrast based on age, weight and creatinine.
- N-acetylcysteine
- Sodium Bicarbonate
- Iso-osmolar contrast

- **Contrast Volume = eGFR x 3.7 ml.** *2016 SCAI Expert Consensus Statement; 2018 ESC Guidelines on myocardial revascularization*
- **Contrast Volume = eGFR x 2.5 ml.** *Circ Cardiovasc Interv. 2015;8:e001859*
- **Contrast Volume = eGFR x 2.0 ml.** *Gurm et al. J Am Coll Cardiol , 2011, vol. 58 (pg. 907-914)*
- **Contrast Volume = eGFR x 1.0 ml.** *Brown et al. Circ Interv 2010;3:346-350*

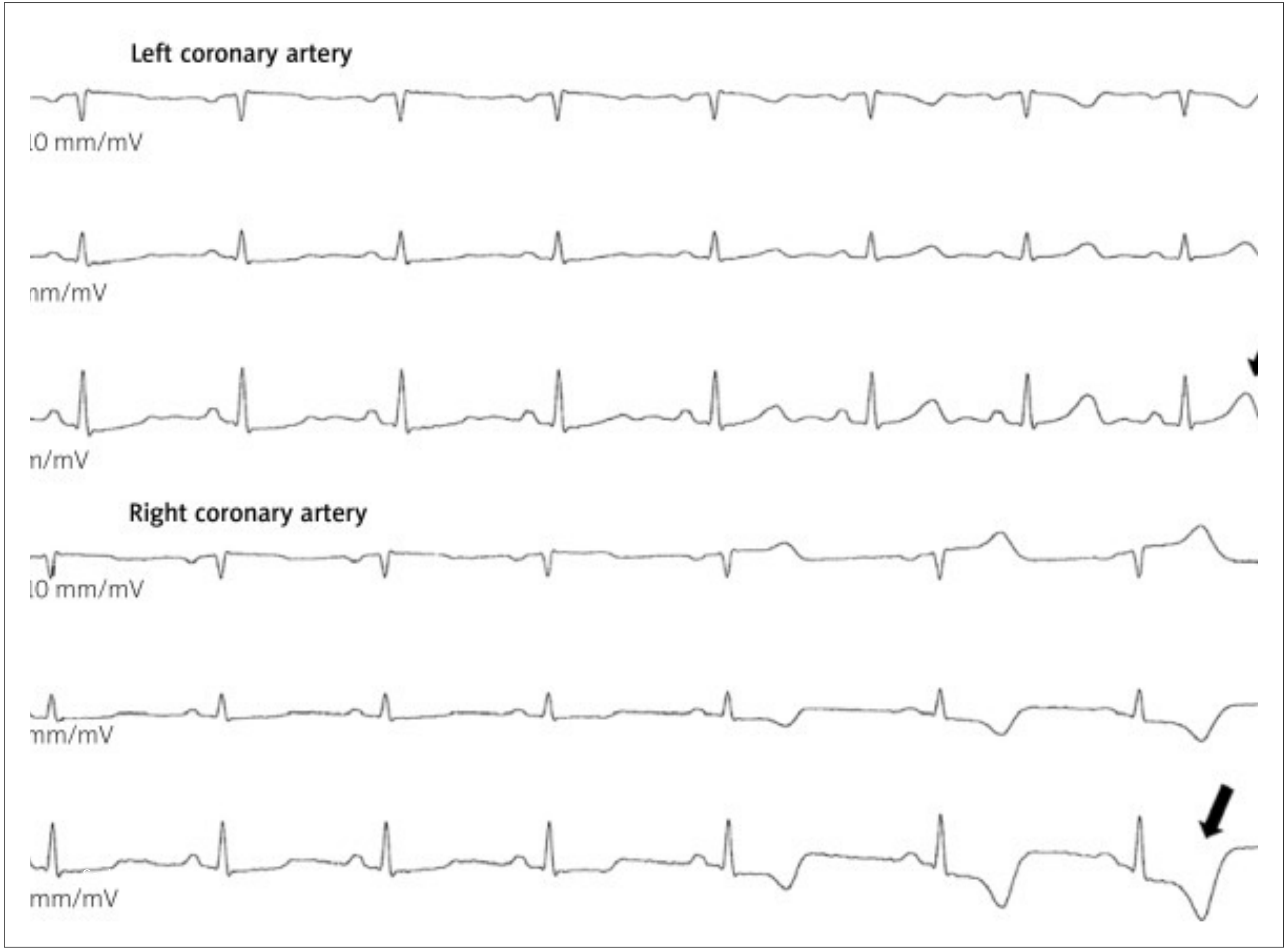
Hydration



Brar et al. Lancet. 2014

Basics

- Femoral versus radial access
- Nonionic, iso-osmolar contrast preferred
- Consider preserving radial artery for AV fistula
- Reliable angiography <15 mL



CATHETER ENGAGEMENT

- High frame acquisition (30 f/s) to recognize calcium
- Inject 10-20ml of saline and observe temporal ST-changes
- Introduce guidewire
  - Requires heparin
  - Usually only if planning PCI
- Left coronary: 2-3 mL
- Right coronary: 2 mL or less

Fluid Volumes in equipment

Catheter	Catheter alone [ml]	Catheter with manifold [ml]	Catheter with Y connector [ml]
Diagnostic 5 Fr	1.3	1.6	2.6
Diagnostic 6 Fr	1.6	1.9	2.9
Guide 6 Fr	2.6	2.9	3.9
Guide 7 Fr	3.3	3.6	4.6

Since blood flow elutes some contrast from the end of the catheter, the real contrast volume contained in the above systems is approximately 0.5–1.0 ml less. The inner diameters of the catheters were as follows: diagnostic – 0.05" (5 Fr); 0.57" (6 Fr); and guide – 0.71" (6 Fr); 0.081" (7 Fr).

Jerzy Sacha *et al.* Limited contrast use for the prevention of CIN
Advances in Interventional Cardiology 2019; 15, 2 (56)

Diagnostic Angiography

- Left Coronary
  - LAO CAUDAL
  - RAO CRANIAL
- Right coronary
  - LAO CRANIAL
- Consider dilution with saline 2:1–may limit visualization
- Biplane angiography
  - Proven to decrease risk of CIN
  - Does not increase radiation

Low Contrast PCI

Anatomical landmarks

- Calcifications within vessels and chest wall
- Overlying ribs
- Diaphragm
- Surgical clips
- Catheter position

Guidewire tip can estimate vessel length

Use IVUS and IVUS “marking:

- Estimate lesion length, vessel diameter and landing zone

"Marking" Wire concept

Final angiography (1-2 mL) excludes:

- Vessel perforation
- Distal embolization

Dynamic Coronary Roadmap (DCR)

Co-Registration

Intravascular Ultrasound (IVUS)

IntraSight Technology

DyeVert

Stent Boost Live

Ultra-Low or Zero Contrast PCI

IVUS: the MOZART Trial

- 83 patient assigned to angiography or IVUS-guided PCI
- Demonstrated safety and significant decrease in contrast
- No hard endpoints
- Relatively good renal function
- No clinical benefit

Primary endpoint	Angiography-guided (n=42)	IVUS-guided (n=41)	P
Total contrast volume, ml	71.4 ± 35.9	22.9 ± 12.5	<0.001

Table 4

Iodine contrast utilization and procedural characteristics

	Angiography-guided (n=42 pts)	IVUS-guided (n=41 pts)	p-value
Total contrast volume, ml*	64.5 (42.8 – 97.0)	20.0 (12.5 – 30.0)	<0.001
Volume of contrast per stent implanted, ml	40.5 (25.7 – 48.3)	13.0 (7.1 – 20.0)	<0.001
Contrast volume/creat. clearance ratio	1.0 (0.6 – 1.9)	0.4 (0.2 – 0.6)	<0.001
Contrast volume/creat. clearance ratio >2	19.0	4.9	0.09
Procedure time, min	34.0 (18.5 – 54.5)	48.0 (34.0 – 61.0)	0.006
Fluoroscopic time, min	12.2 (6.8 – 24.1)	12.2 (8.4 – 20.8)	0.5
Number of cine runs	22.5 (16.0 – 36.3)	25.0 (19.0 – 32.5)	0.5
Cumulative DAP, Gy × cm^2	82.1 (54.5 – 132.0)	73.7 (44.8 – 118.3)	0.4
Cumulative air Kerma, Gy	1.4 (1.0 – 2.7)	1.4 (1.0 – 2.0)	0.3

*Primary endpoint

Numbers are percentage or median (interquartile range)

Creat. = creatinine; DAP=dose-area product

Table 5

In-hospital and 4-monthoutcomes*

	Angiography-guided (n=42 pts)	IVUS-guided (n=41 pts)	p-value
In hospital			
Death	0	0	-
Acute myocardial infarction†	4.8	4.9	>0.9
Unplanned revascularization	0	0	-
Stent thrombosis	0	0	-
CK-MB rise > 5X ULN	11.9	14.6	0.8
CK-MB peak, ng/ml	2.4 (1.3 – 3.7)	2.5 (1.1 – 9.4)	0.5
Peak serum creatinine, mg/dl	1.2 (1.0 – 1.5)	1.3 (1.0 – 1.6)	0.4
Lowest creatinine clearance, ml/min/1.73 m2	61.9 (43.8 – 79.1)	51.4 (40.5 – 72.9)	0.3
Peak rise in creatinine > 0.5 mg/dl	19.0	7.3	0.2
4-month post-discharge			
Death	0	4.2	0.3
Acute myocardial infarction‡	3.3	4.2	>0.9
Unplanned revascularization	11.7	4.2	0.3
Stent thrombosis	0	0	-
Any event	11.7	4.2	0.3

Numbers are percentage or medianinterquartile interval)

CKMB = creatine kinase-MB; URL = upper reference limit

*Kaplan-Meier estimates
†All post-PCI
‡All spontaneous

Mariani et al 2014

European Heart Journal
doi:10.1093/eurheartj/ehw078

EHJ BRIEF COMMUNICATION
Interventional cardiology

Imaging- and physiology-guided percutaneous coronary intervention without contrast administration in advanced renal failure: a feasibility, safety, and outcome study

Ziad A. Ali[1,2*], Keyvan Karimi Galougahi[1], Tamim Nazif[1,2], Akiko Maehara[1,2], Mark A. Hardy[3], David J. Cohen[4], Lloyd E. Ratner[3], Michael B. Collins[1,2], Jeffrey W. Moses[1,2], Ajay J. Kirtane[1,2], Gregg W. Stone[1,2], Dimitri Karmpaliotis[1,2], and Martin B. Leon[1,2]

[1]Division of Cardiology, Center for Interventional Vascular Therapy, New York Presbyterian Hospital and Columbia University, New York, NY, USA; [2]Cardiovascular Research Foundation, New York, NY, USA; [3]Department of Surgery, New York Presbyterian Hospital and Columbia University, New York, NY, USA; and [4]Division of Nephrology, New York Presbyterian Hospital and Columbia University, New York, NY, USA

Received 21 December 2015; revised 10 January 2016; accepted 3 February 2016

PCI, physiology, IVUS, and follow-up data

Procedure time (min)	72 [61, 119]
Fluoroscopy time (min)	20 [16, 35]
Radiation dose (mGy)	1154 [538, 1932]
Follow-up (days)	79 [33, 207]
Follow-up eGFR (mL/min/1.73 m^2)	18 [14, 22]
Change in eGFR (mL/min/1.73 m^2)	−0.2 [−1.4, 1.8]

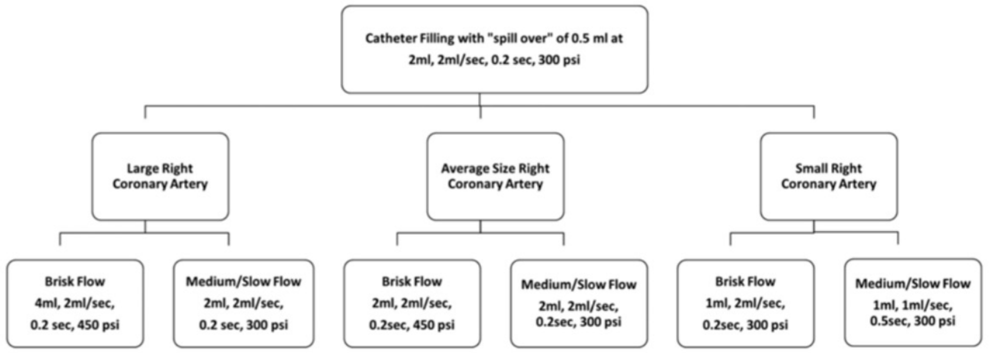
Renal replacement therapy	0 (0)
Stent thrombosis	0 (0)
Revascularization	0 (0)
MI	0 (0)
Death	0 (0)

Ali et al. 2016

Zero-contrast PCI

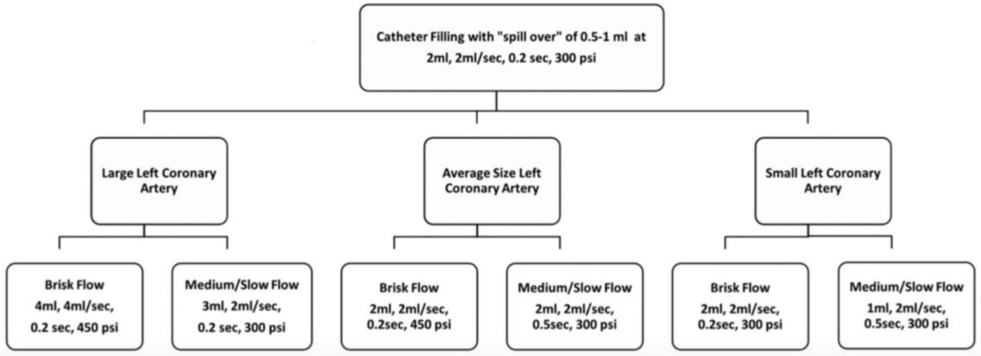
- No patient received contrast during PCI
- Combination of intravascular ultrasound and physiology
- Diagnostic angiography completed at least 7 days prior
- Goal: Contrast Volume/eGFR <1

Ultra-low contrast delivery technique
Right coronary artery automatic injector algorithm



Stys a, *et al*. Feb 2011. Adv in Interv Cardiol 1(1):8-14

Ultra-low contrast delivery technique
Left coronary artery automatic injector algorithm



Stys a, *et al*. Feb 2011. Adv in Interv Cardiol 1(1):8-14

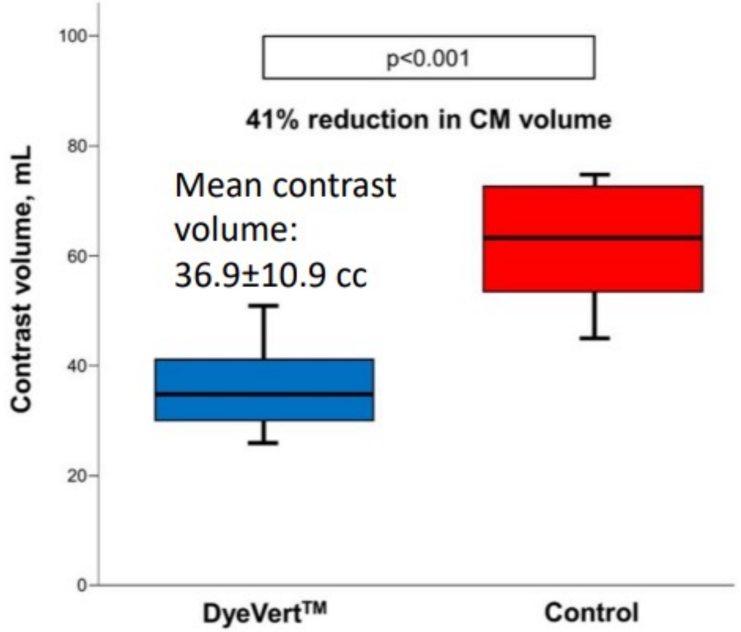
DYEVERT

Impact of a novel contrast reduction system on contrast savings in coronary angiography – The DyeVert randomised controlled trial

Steffen Desch [a,b,c,*,1], Georg Fuernau [b,c,1], Janine Pöss [b,c,1], Roza Meyer-Saraei [b,c,1], Mohammed Saad [b,c,1], Ingo Eitel [b,c,1], Holger Thiele [a,1], Suzanne de Waha [b,c,1]

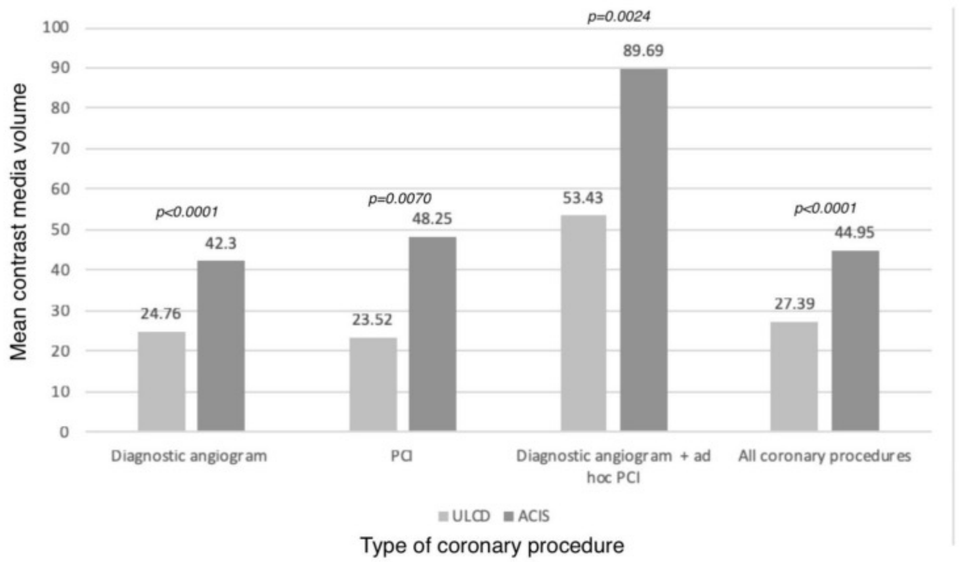
Table 1
Baseline characteristics.

	DyeVert™ (n = 48)	Control (n = 48)	P-Value
Age (years)	68.6 ± 13.6	66.2 ± 12.8	0.39
Male gender, n (%)	28 (58.3)	28 (58.3)	1.00
BMI (kg/m^2)	28.9 ± 6.6	28.0 ± 4.3	0.46
Known coronary artery disease, n (%)	15 (31.3)	17 (35.4)	0.83
Prior PCI, n (%)	11 (22.9)	13 (27.1)	0.81
Congestive heart failure, n (%)	20 (41.7)	19 (39.6)	1.00
NYHA I, n (%)	0 (0)	0 (0)	0.09
NYHA II, n (%)	4 (20.0)	9 (47.4)	
NYHA III, n (%)	15 (75.0)	8 (42.1)	
NYHA IV, n (%)	1 (5.0)	1 (5.3)	
No information, n (%)	0 (0)	1 (5.3)	
Known peripheral artery disease, n (%)	8 (16.7)	8 (16.7)	1.00
Arterial hypertension, n (%)	35 (72.9)	34 (70.8)	1.00
Diabetes mellitus, n (%)	6 (12.5)	8 (16.7)	0.77
Chronic kidney disease, n (%)	33 (68.8)	37 (77.1)	0.49
Stage 1, n (%)	5 (15.2)	0 (0)	0.008
Stage 2, n (%)	14 (42.4)	25 (67.6)	
Stage 3, n (%)	11 (33.3)	8 (21.6)	
Stage 4, n (%)	3 (9.1)	1 (2.7)	
Stage 5, n (%)	0 (0)	3 (8.1)	
Anaemia, n (%)	5 (10.4)	8 (16.7)	0.55

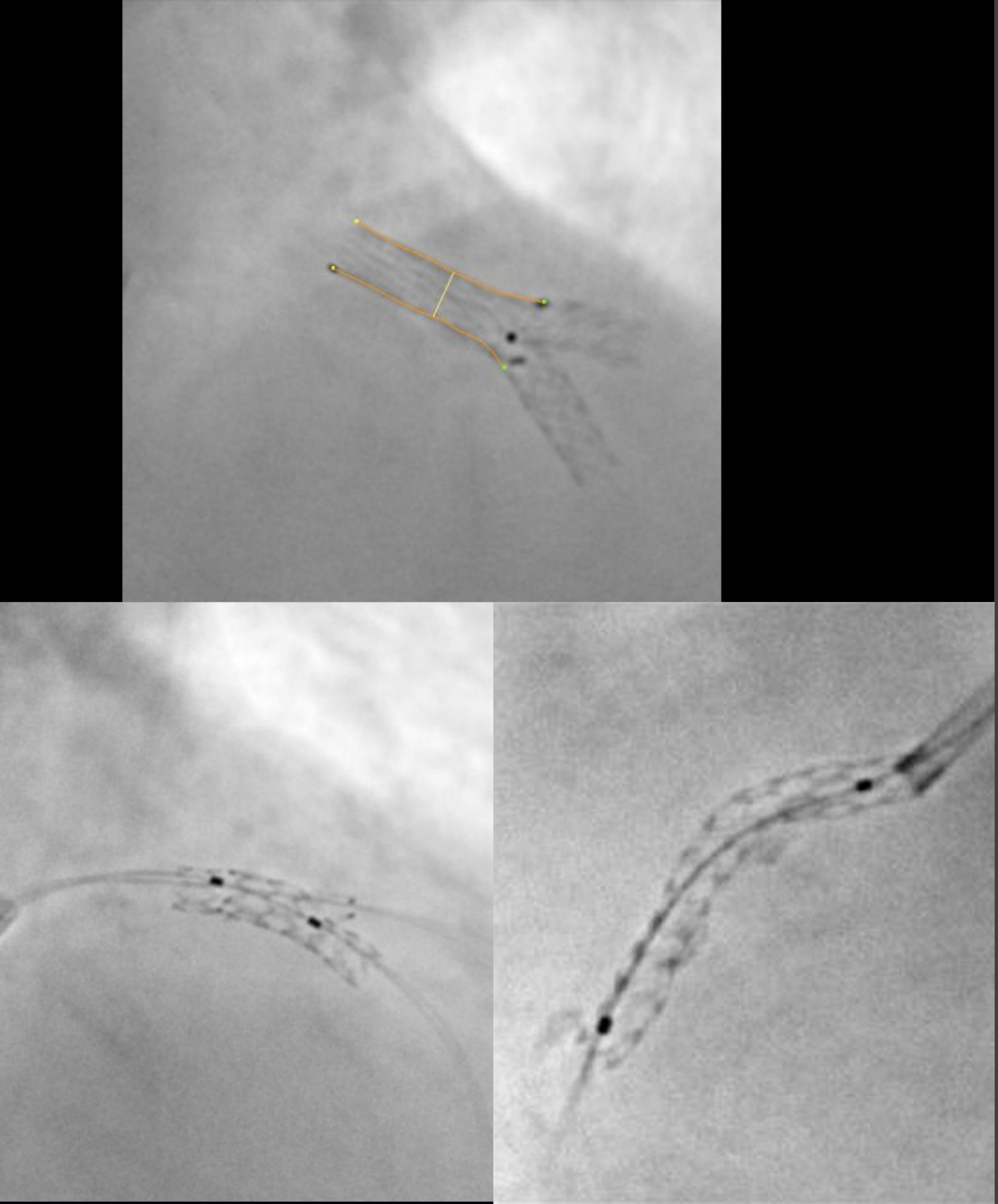


Desch et al, Int J Cardiol. 2018 Apr 15;257:50-53.

Contrast volume per patient using ULCD technique vs. ACIST



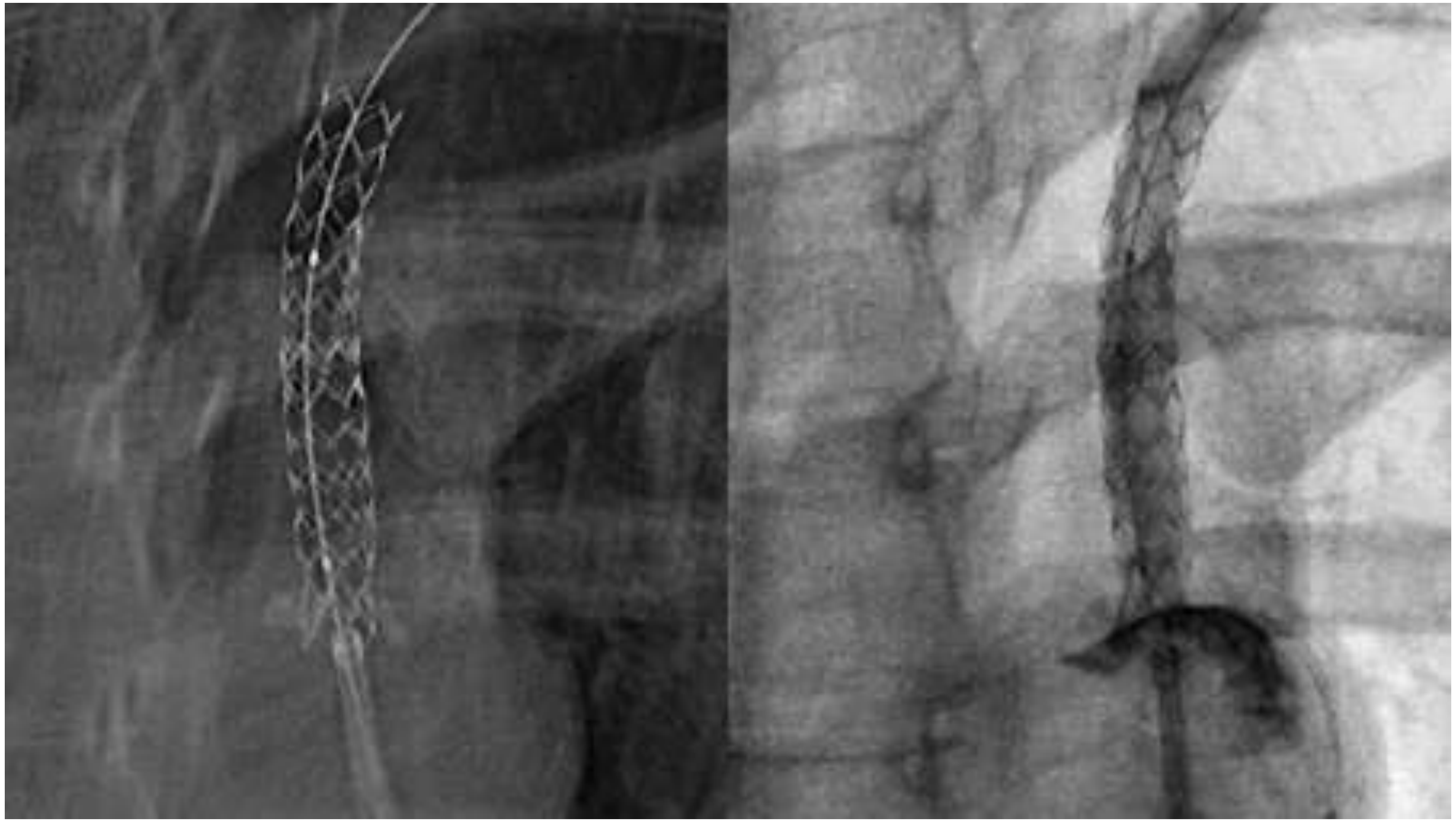
DYEVERT



STENT BOOST

- Noninvasive
- Fast
- Enhances the stent
- Fades out the background
- Allows for precise positioning
- Automatic detection of balloon markers

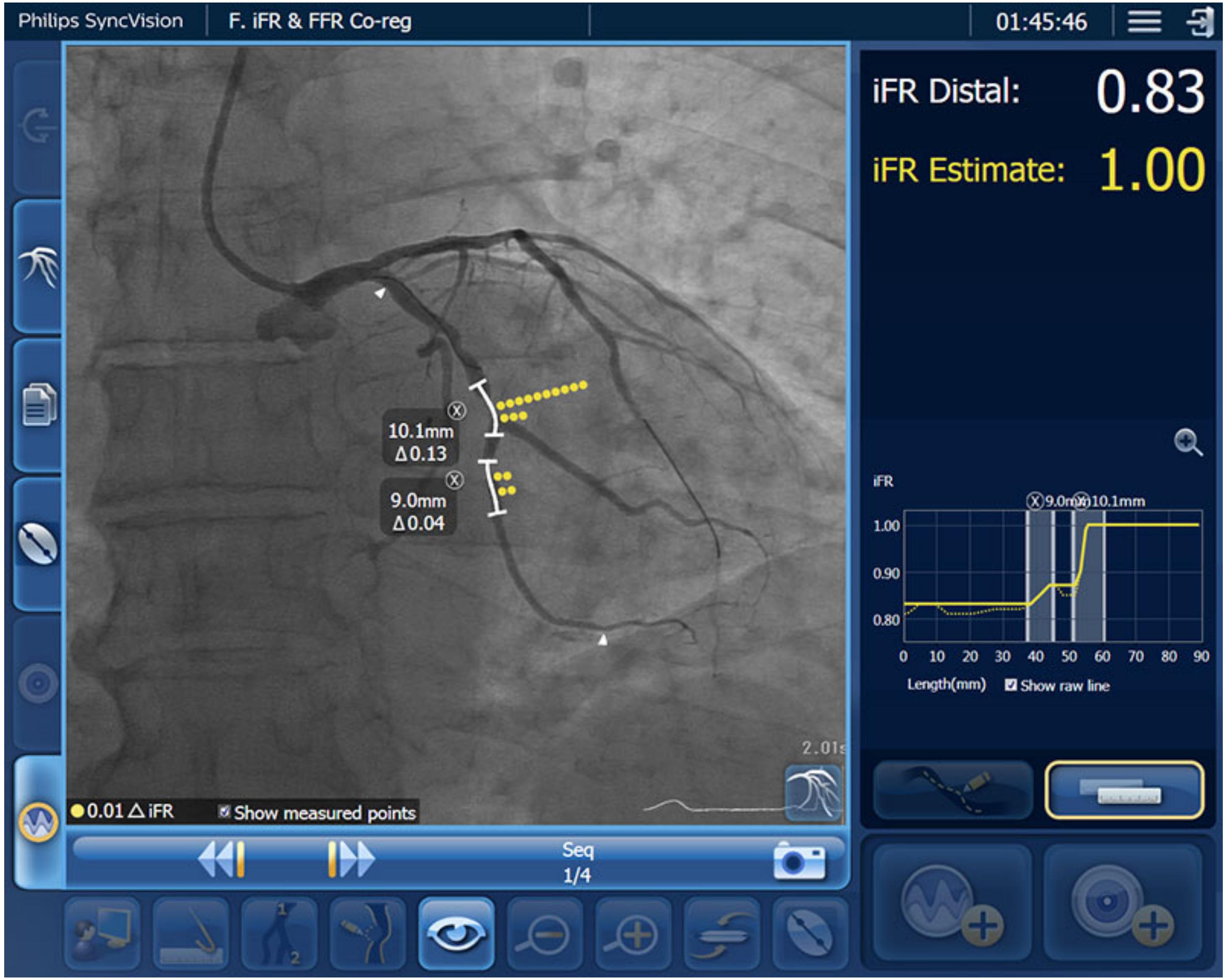
Philips image on file



- Stent Boost Subtraction
  - Image in relation to vessel wall
  - Especially useful for bifurcation and ostial stenting
- Stent Boost Live
  - Rotation of images
  - Zoom and integrate content

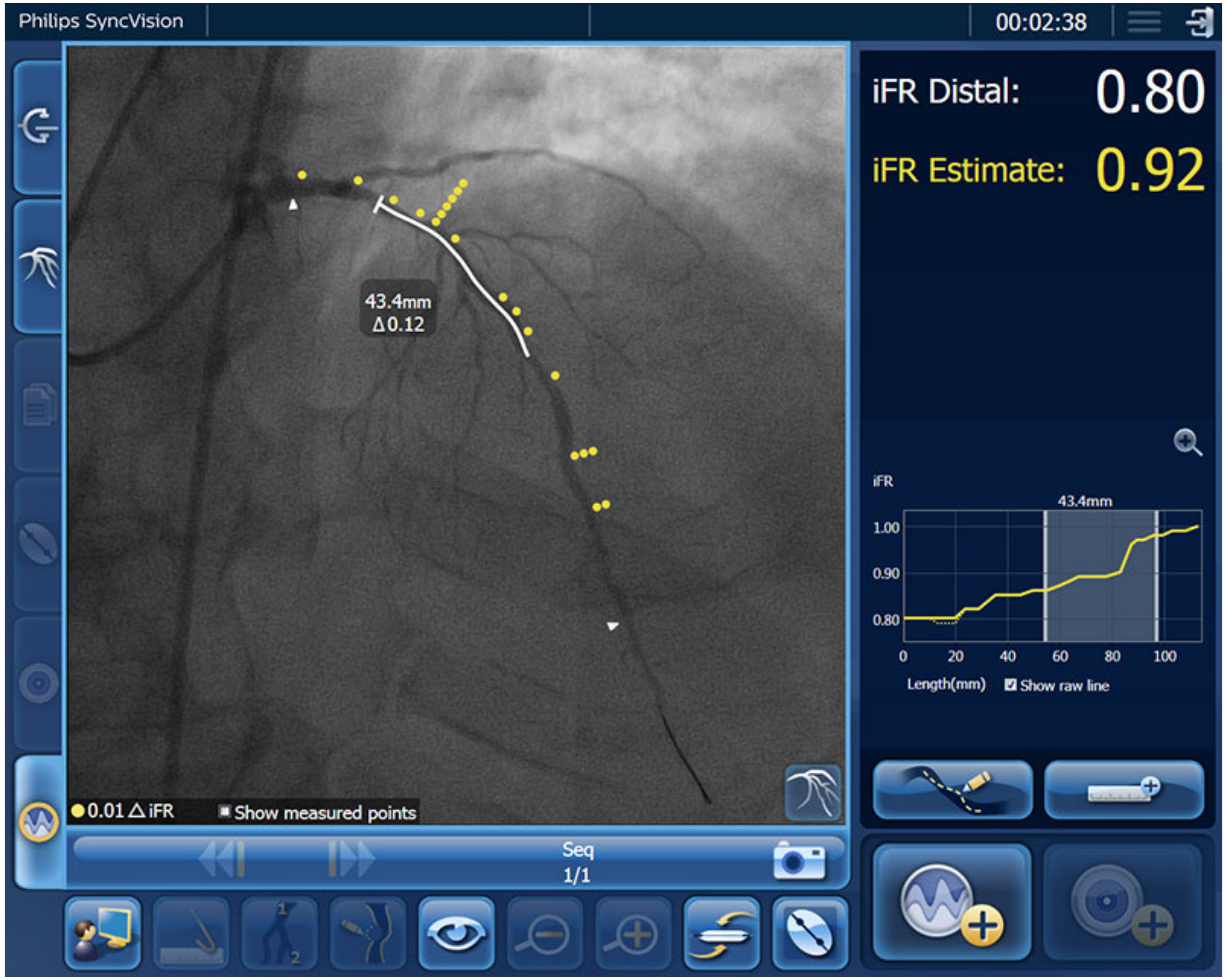
Co-Registration

- Various techniques
- Newer IVUS and OCT platforms are providing this information
- iFR Co-registration: estimate the physiologic impact of a virtual stent



CO-REGISTRATION:

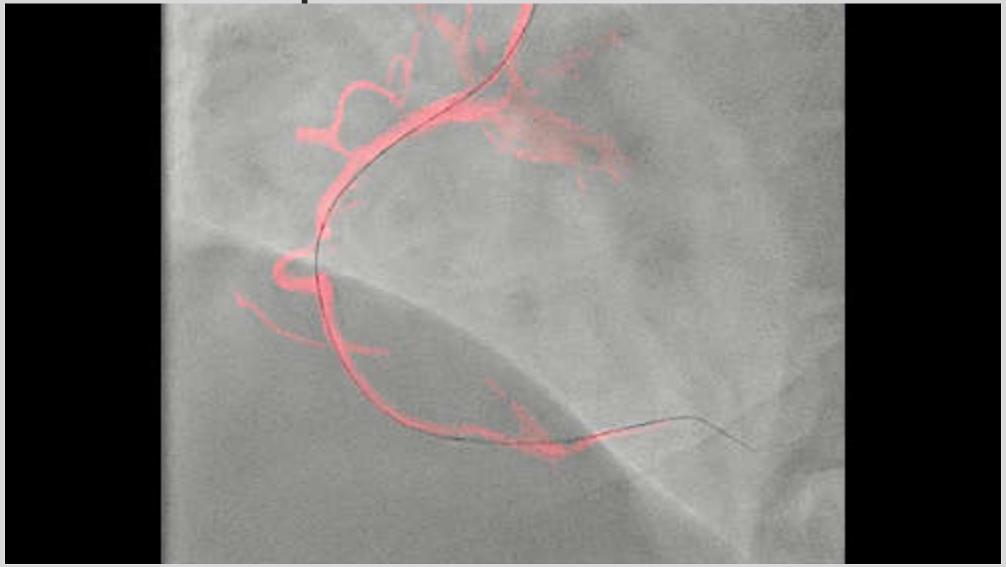
FOCAL DISEASE

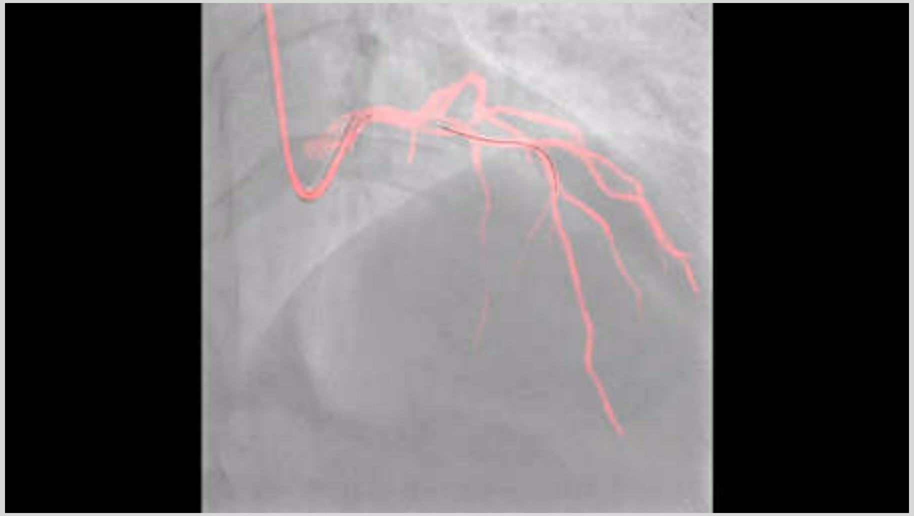


CO-REGISTRATION DIFFUSE DISEASE

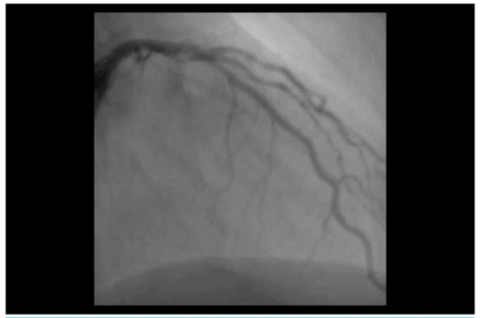
Dynamic Coronary Roadmap

- Real-time, automatic imaging
- Motion-compensated
- Integrated
- Does not change workflow



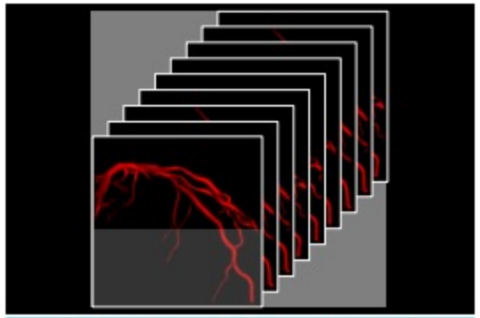


Dynamic Coronary Roadmap – Technology

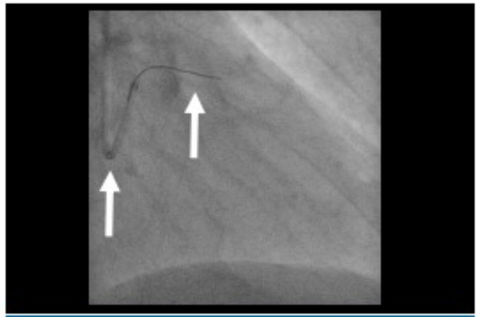


Angiograms are analyzed with contrast density

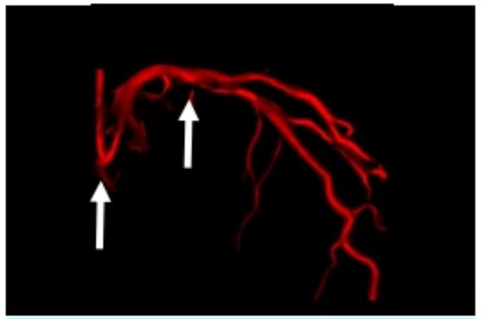
Angiograms are converted into masks



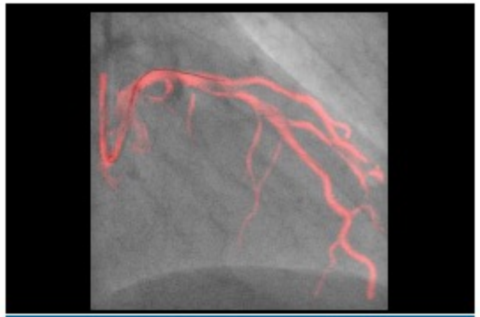
Masks for one heart cycle are stored in a library



Analysis of guide catheter and wire shape

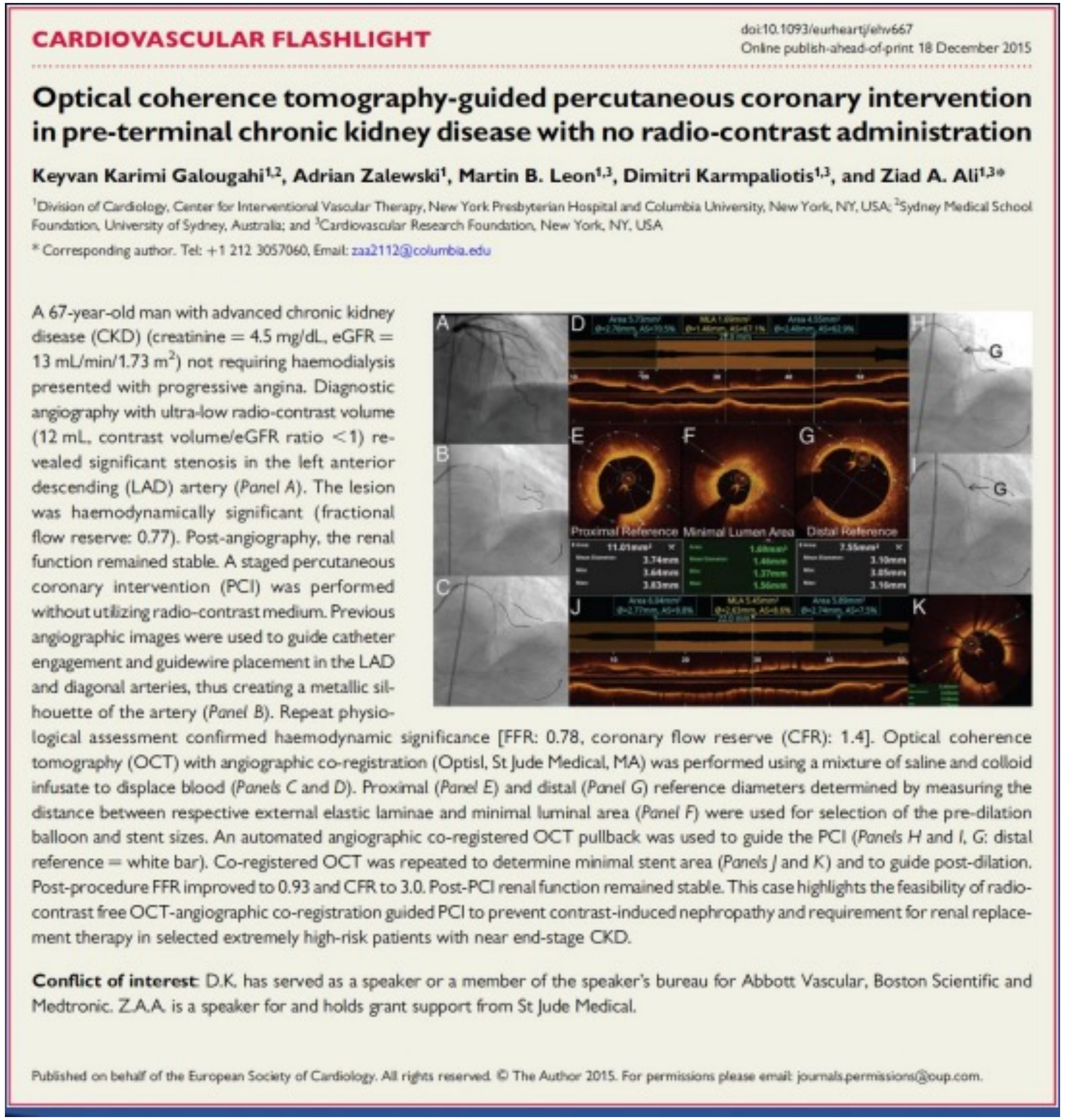


Search library for mask with similar shapes



Fuse mask with fluoroscopy image

Philips image on file



CARDIOVASCULAR FLASHLIGHT

doi:10.1093/eurheartj/ehv667
Online publish-ahead-of-print 18 December 2015

Optical coherence tomography-guided percutaneous coronary intervention in pre-terminal chronic kidney disease with no radio-contrast administration

Keyvan Karimi Galougahi[1,2], Adrian Zalewski[1], Martin B. Leon[1,3], Dimitri Karmpaliotis[1,3], and Ziad A. Ali[1,3]*

[1]Division of Cardiology, Center for Interventional Vascular Therapy, New York Presbyterian Hospital and Columbia University, New York, NY, USA; [2]Sydney Medical School Foundation, University of Sydney, Australia; and [3]Cardiovascular Research Foundation, New York, NY, USA

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A 67-year-old man with advanced chronic kidney disease (CKD) (creatinine = 4.5 mg/dL, eGFR = 13 mL/min/1.73 m^2) not requiring haemodialysis presented with progressive angina. Diagnostic angiography with ultra-low radio-contrast volume (12 mL, contrast volume/eGFR ratio <1) revealed significant stenosis in the left anterior descending (LAD) artery (*Panel A*). The lesion was haemodynamically significant (fractional flow reserve: 0.77). Post-angiography, the renal function remained stable. A staged percutaneous coronary intervention (PCI) was performed without utilizing radio-contrast medium. Previous angiographic images were used to guide catheter engagement and guidewire placement in the LAD and diagonal arteries, thus creating a metallic silhouette of the artery (*Panel B*). Repeat physiological assessment confirmed haemodynamic significance [FFR: 0.78, coronary flow reserve (CFR): 1.4]. Optical coherence tomography (OCT) with angiographic co-registration (OptisI, St Jude Medical, MA) was performed using a mixture of saline and colloid infusate to displace blood (*Panels C* and *D*). Proximal (*Panel E*) and distal (*Panel G*) reference diameters determined by measuring the distance between respective external elastic laminae and minimal luminal area (*Panel F*) were used for selection of the pre-dilation balloon and stent sizes. An automated angiographic co-registered OCT pullback was used to guide the PCI (*Panels H* and *I*, G: distal reference = white bar). Co-registered OCT was repeated to determine minimal stent area (*Panels J* and *K*) and to guide post-dilation. Post-procedure FFR improved to 0.93 and CFR to 3.0. Post-PCI renal function remained stable. This case highlights the feasibility of radio-contrast free OCT-angiographic co-registration guided PCI to prevent contrast-induced nephropathy and requirement for renal replacement therapy in selected extremely high-risk patients with near end-stage CKD.

Conflict of interest: D.K. has served as a speaker or a member of the speaker's bureau for Abbott Vascular, Boston Scientific and Medtronic. Z.A.A. is a speaker for and holds grant support from St Jude Medical.

OCT

- Few Reports
- Co-Registration
- Automatic measures

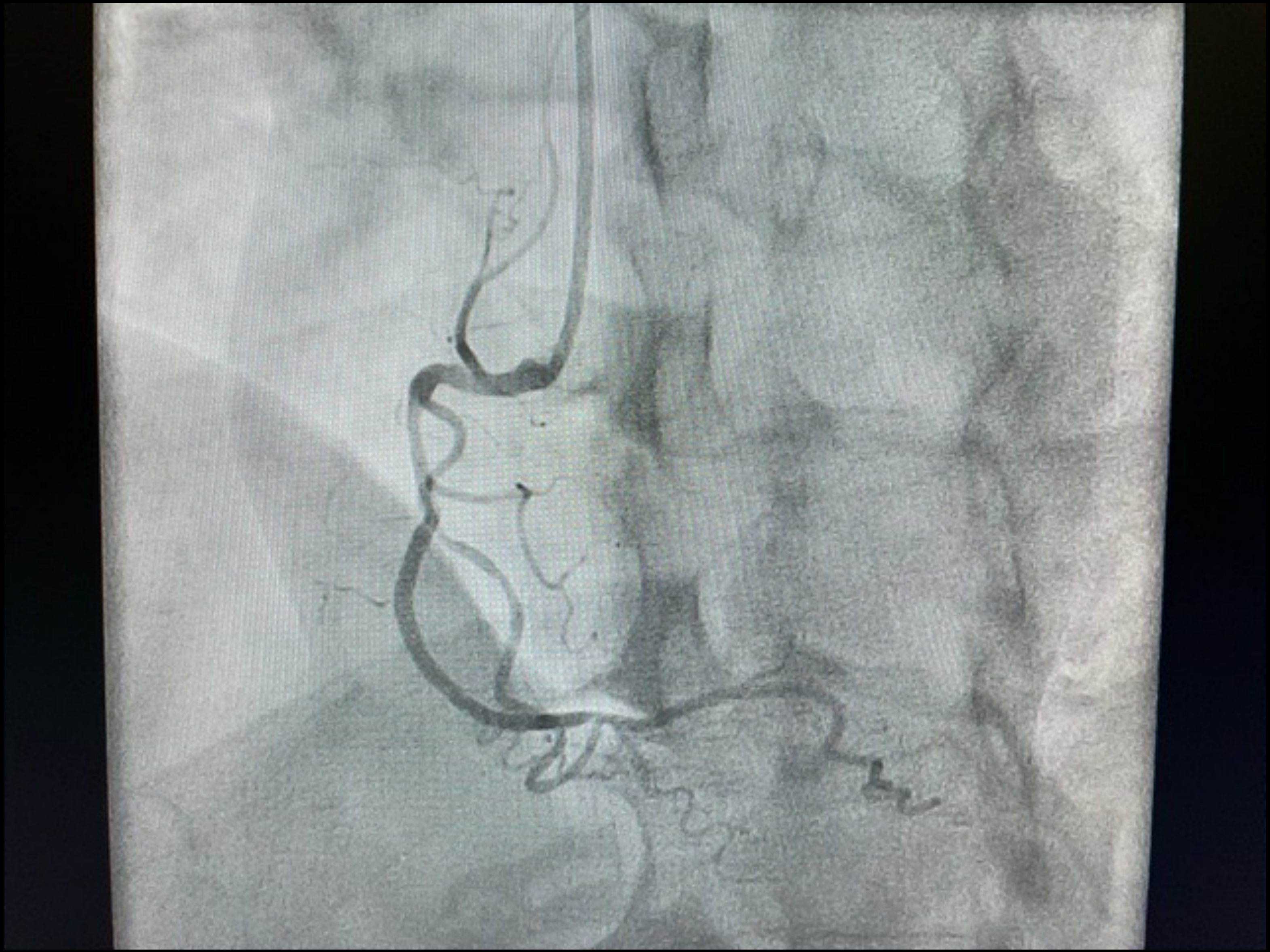
- Non-contrast Solutions
  - Normal Saline
  - Low molecular weight dextran-40

JF   53 year-old with accelerating angina

- Hx Anterior STEMI, PCI to LAD
  - Known OM disease

- Ischemic cardiomyopathy, LVEF 45%
- Hypertension
- Dyslipidemia
- Diabetes Mellitus

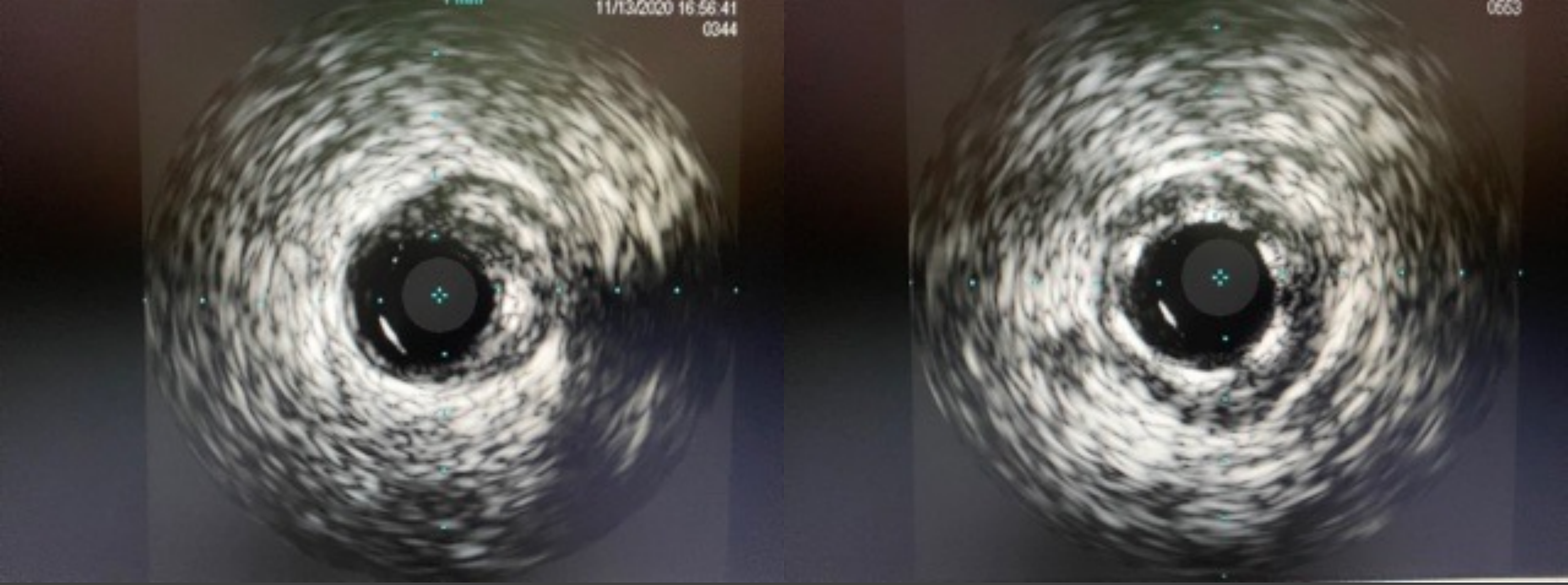
- CKD with creatinine 2.5 and calculated creatinine clearance 26 mL/min
  - Followed by nephrology



- Proximal LAD disease
- T wave inversions anteriorly
- Decision to proceed with physiology

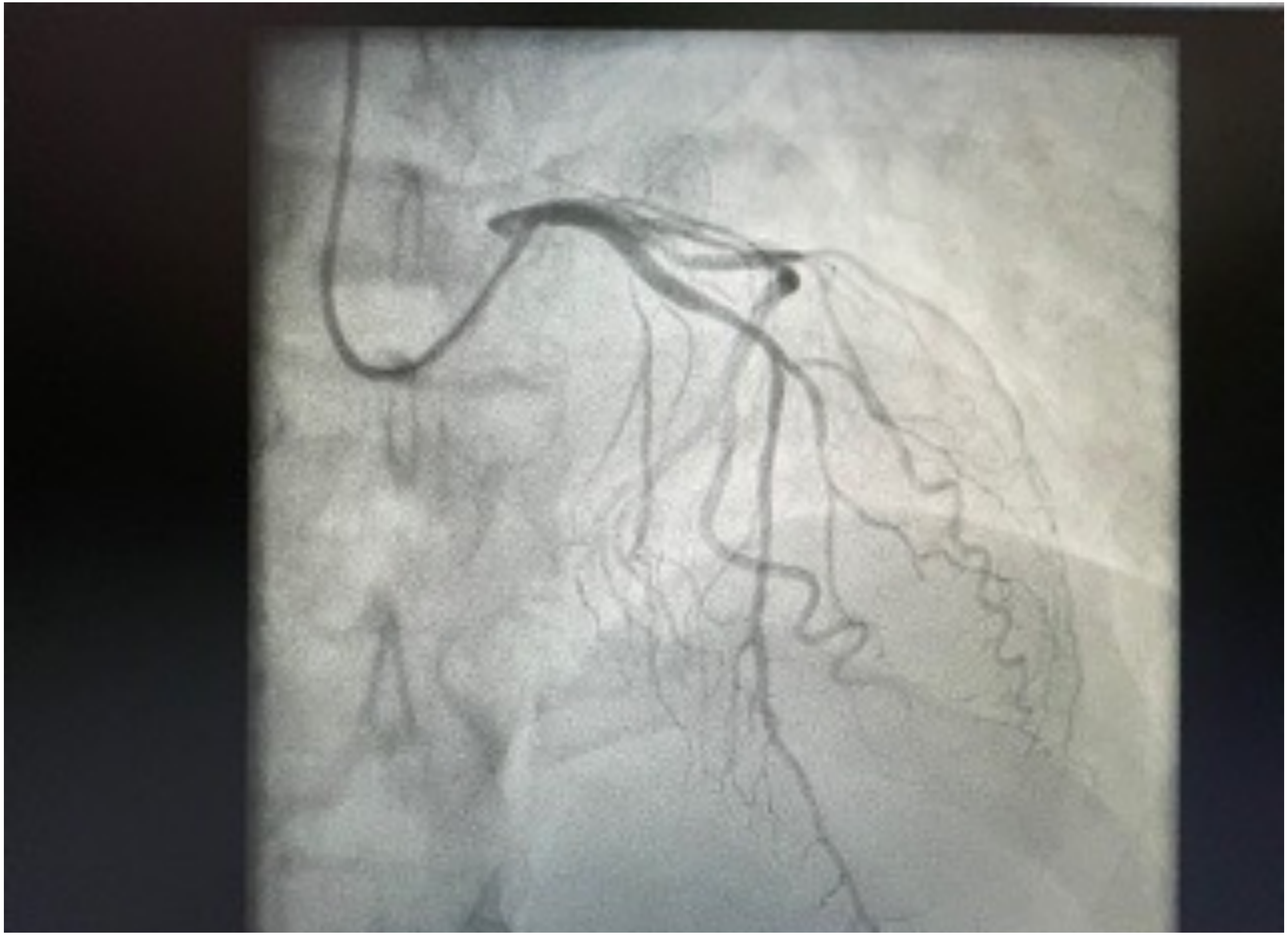
0:26
iFR®
Distal
0.80
List of Runs
iFR
FFR
04:39:40 PM
1.00
RCA
04:39:57 PM
1.01
RCA
04:50:01 PM
0.81
04:50:26 PM
0.80
Pullback
0.90
0.80
0.70
0.60
iFR
5
10
15
20
25
200
150
100
50
0
mmHg
Live
Options
Save Frame
Settings
Patient
FFR
iFR
Select Mode
iFR Pullback complete

IVUS/IVUS MARKING



STENT UNDEREXPANSION

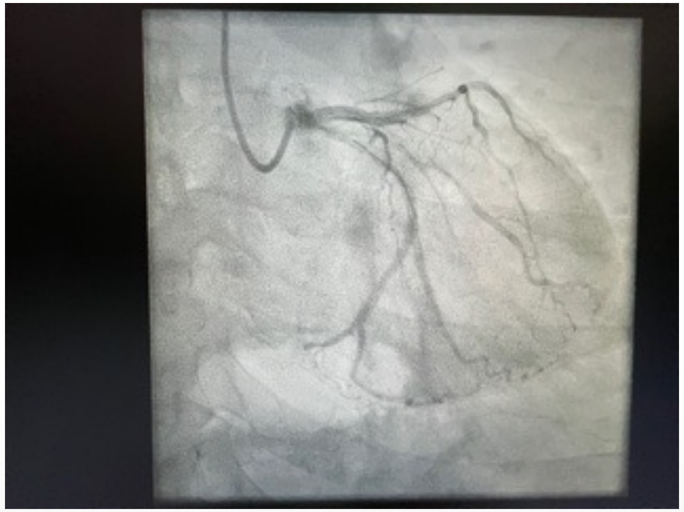
STENT BOOST



RESULTS

- Total contrast 19 cc
- Creatinine one week later 2.7
- Remains angina free one year later





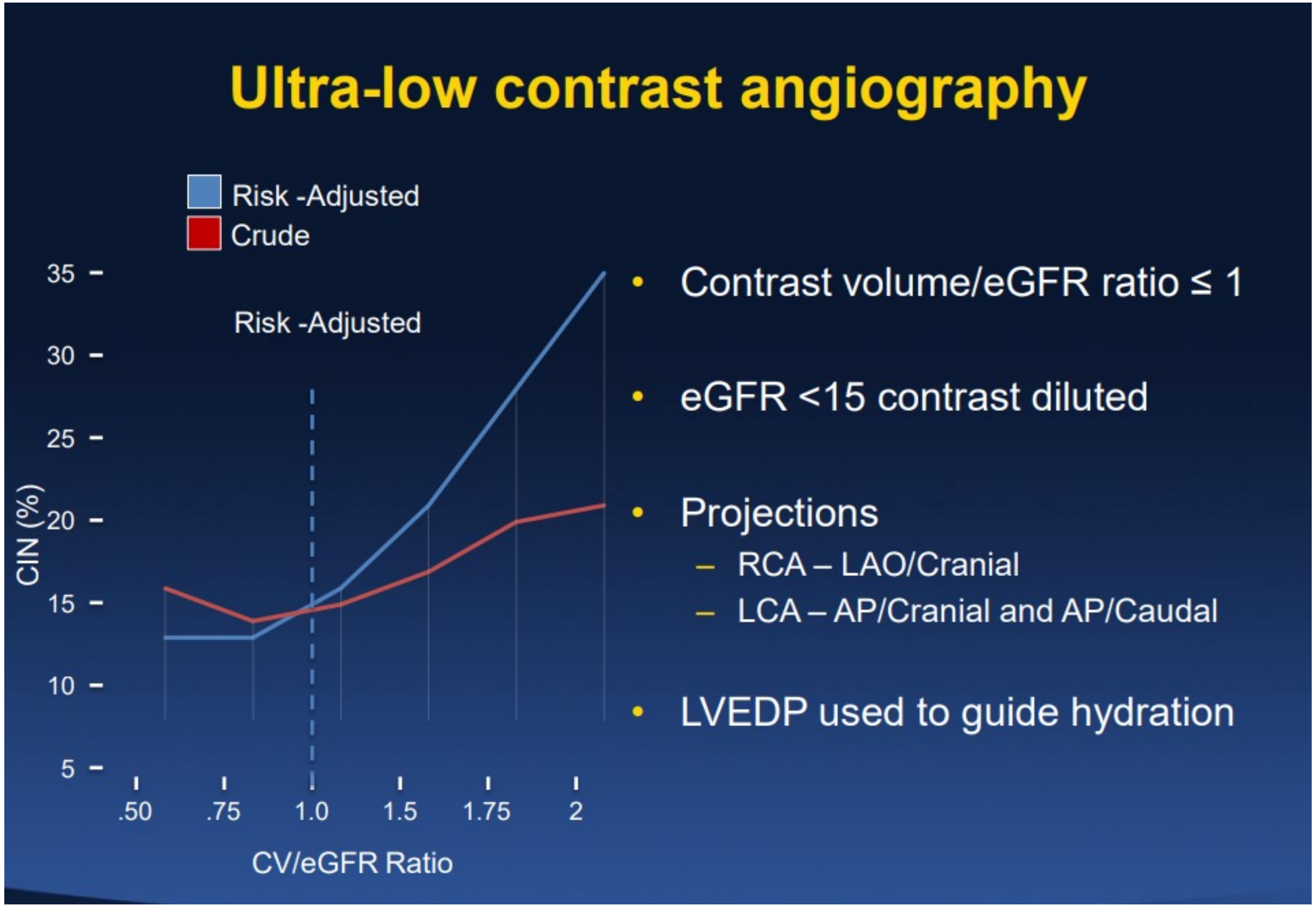
85 year old with NSTEMI

- DM
- HTN
- HF, EF 35%
- Repeat admission
- Failed medical therapy
- GFR 19


6 Fr
Reference
2.7mm
72%
Vessel Enhancement Image
Len: 16.7mm
MLD: 0.7mm(72%)
Ref (Avg): 2.5mm
04/08/2020 17:08:19
Press here to add text...
Seq
3/3


Post-procedure

- Final contrast total 7 cc
- Creatinine remained stable
- Angina-free
- No readmissions since PCI



Summary

- Implement in daily practice
- Almost all interventional techniques can be used
- Monitor hemodynamics
- Benefits of Early invasive strategy are preserved in patients with CKD

QUESTIONS?

Thank you