

第53回北陸循環器核医学研究会

**心臓CT時代における
SPECT/CT Fusion Imageの有用性**

医療法人 天神会
新古賀病院 心臓血管センター

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心臓CTのパフォーマンス

冠動脈病変の性状評価

- プラークの診断・評価
- QCA情報
- QCU情報
- etc.

スクリーニング

- 狭心症
- 不安定狭心症
- 非ST上昇型心筋梗塞
- 非定型的胸痛
- ハイリスク患者, etc.

フォローアップ

- PCI(ステント)後
- CABG後
- 薬物加療後
- etc.

冠動脈硬化症の評価

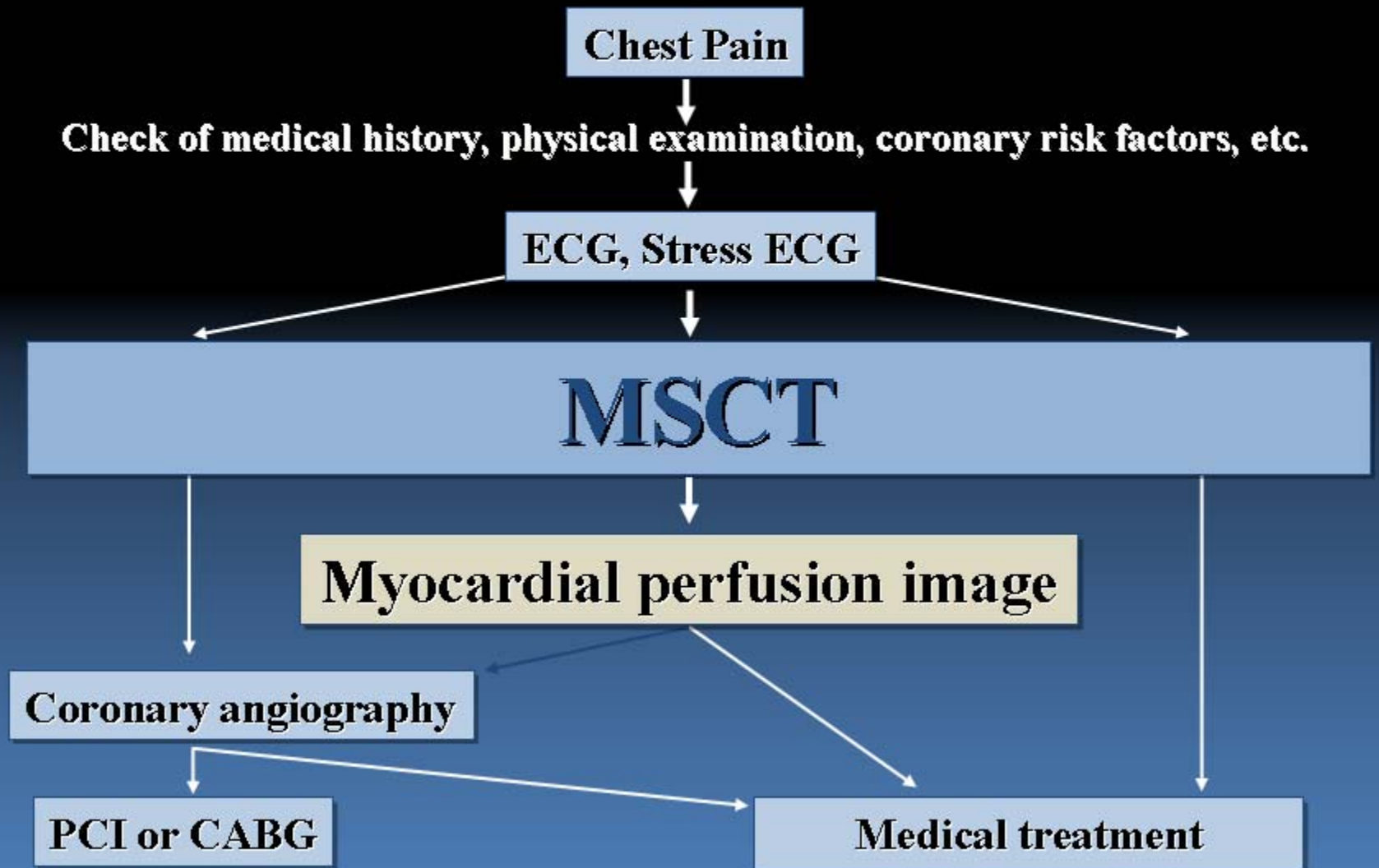
- 石灰化スコア
- 心臓周囲脂肪との関連

左心機能の評価

- EDV
- ESV
- LVEF

**Triple Rule Out
予後評価**

Decision making of Chest pain

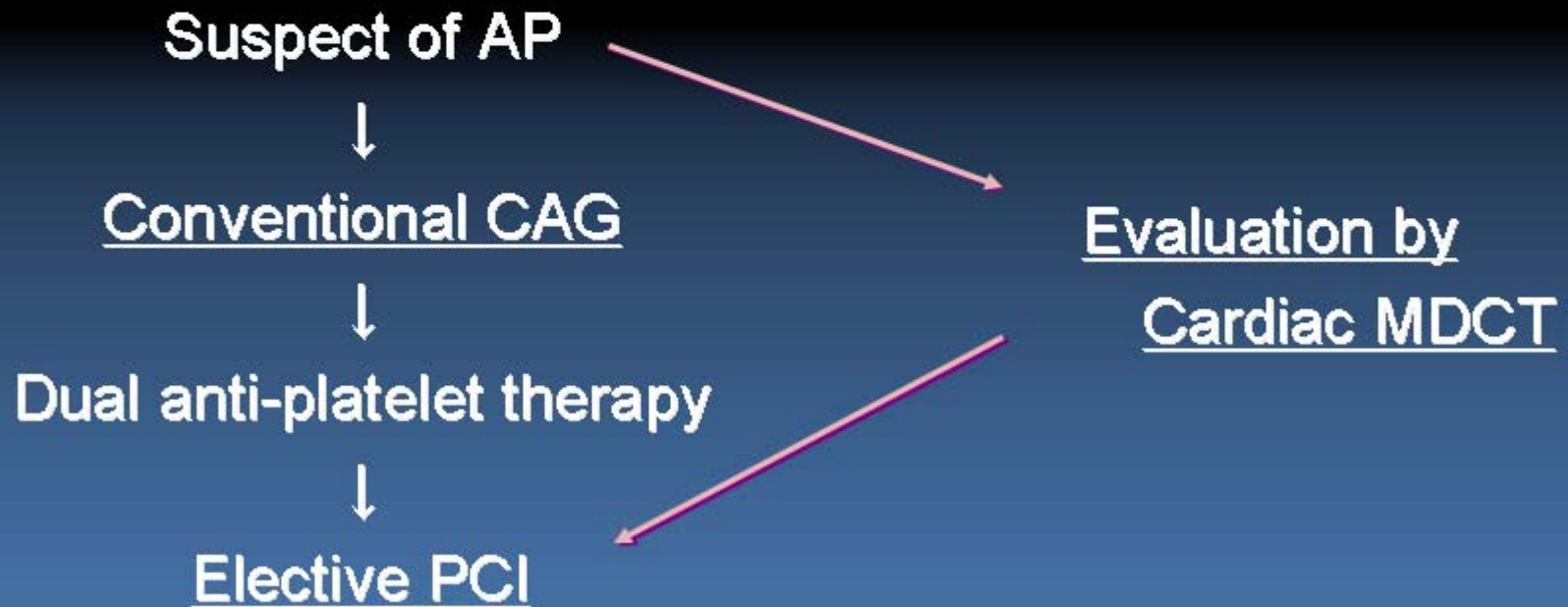


Strategical changes in PCI

Conventional strategy



Recent strategy



心臓CTの限界

Concept of SPECT/CT Fusion Image

心臓MDCT

形態的情報

- ・バイパス評価
 - ・PCI後のフォロー
 - ・冠動脈プラークの評価
 - ・不安定プラークの検出
- 現在evidenceの蓄積中

心筋血流SPECT

機能的情報

- 多くのevidenceがある
- ・虚血性心疾患の診断
 - ・心筋viability評価
 - ・心事故リスクの層別化
 - ・治療効果判定
 - ・予後評価

Discrepancy between abnormal CTA and Ischemia

Eur J Nucl Med Mol Imaging
DOI 10.1007/s00259-006-0307-z

ORIGINAL ARTICLE

Accuracy of 64-slice CT angiography for the detection of functionally relevant coronary stenoses as assessed with myocardial perfusion SPECT

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Abstract

Purpose CT angiography (CTA) offers a valuable alternative for the diagnosis of CAD but its value in the detection of functionally relevant coronary stenoses remains uncertain. We prospectively compared the accuracy of 64-slice CTA with that of myocardial perfusion imaging (MPI) using ^{99m}Tc-tetrofosmin-SPECT as the gold standard for the detection of functionally relevant coronary artery disease (CAD).

Methods MPI and 64-slice CT were performed in 100 consecutive patients. CTA lesions were analysed quantitatively and area stenoses $\geq 50\%$ and $\geq 75\%$ were compared with the MPI findings.

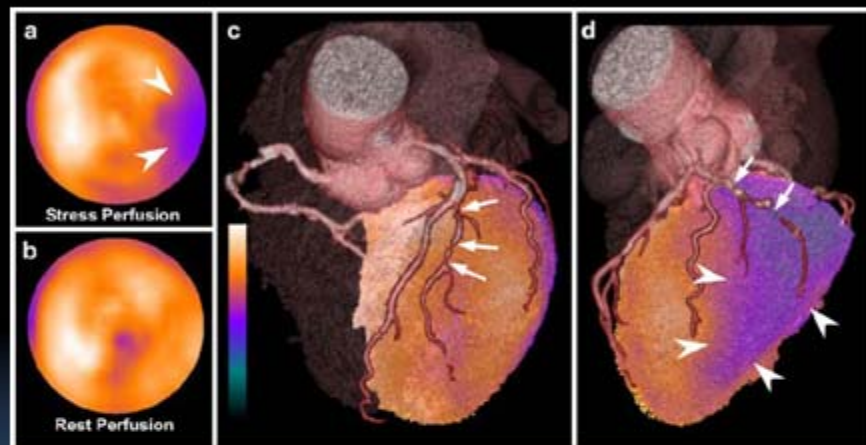
Results In 23 patients, MPI perfusion defects were found (12 reversible, 13 fixed). A total of 399 coronary arteries and 1,386 segments was analysed. Eighty-four segments (6.1%) in 23 coronary arteries (5.8%) of nine patients (9.0%) were excluded owing to insufficient image quality. In the remaining 1,302 segments, quantitative CTA

revealed stenoses $\geq 50\%$ in 57 of 376 coronary arteries (15.2%) and stenoses $\geq 75\%$ in 32 (8.5%) coronary arteries. Using a cut-off at $\geq 75\%$ area stenosis, CTA yielded the following sensitivity, specificity, negative (NPV) and positive predictive value (PPV), and accuracy for the detection of any (fixed and reversible) MPI defect: by patient, 75%, 90%, 93%, 68% and 87%, respectively; by artery, 76%, 95%, 99%, 50% and 94%, respectively. **Conclusion** Sixty-four-slice CTA is a reliable tool to rule out functionally relevant CAD in a non-selected population with an intermediate pretest likelihood of disease. However, an abnormal CTA is a poor predictor of ischaemia.

Keywords Coronary CT angiography · Myocardial perfusion imaging · SPECT · Coronary artery disease

Introduction

In 2003 about 2 million invasive coronary angiography (CA) procedures were performed in Europe [1]. In spite of continuous improvements in CA to minimise the risks inherent in invasive testing, the associated economic burden, the inconvenience to patients and the remaining risk of severe complications have prompted an intensive search for alternative, non-invasive means for coronary artery imaging [2]. Since 1999, multislice spiral computed tomography (MSCT) systems with simultaneous acquisition of four or more slices and gantry rotation times of less than half a second have been available [3]. Compared with CA, multislice CT angiography (CTA) has delivered promising results regarding accuracy in the detection and



64slice CTA is a reliable tool to rule out functionally relevant CAD in a non-selected population with an intermediate pretest likelihood of disease. However, an abnormal CTA is a poor predictor of ischemia.

Eur J Nucl Med Mol Imaging, 2006

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Limitation of CTA

A Randomized Controlled Trial of Multi-Slice Coronary Computed Tomography for Evaluation of Acute Chest Pain

Chest Pain
(Low Risk)

RESULTS:

- Both approaches were completely (100%) safe.
- MSCT evaluation reduced diagnostic time compared with SOC (3.4 h vs. 15.0 h, $p < 0.001$) and lowered costs (\$1,586 vs. \$1,872, $p < 0.001$).

(n=67)

Non-diagnostic
(n=24)

(n=8)

Nuclear Stress Study

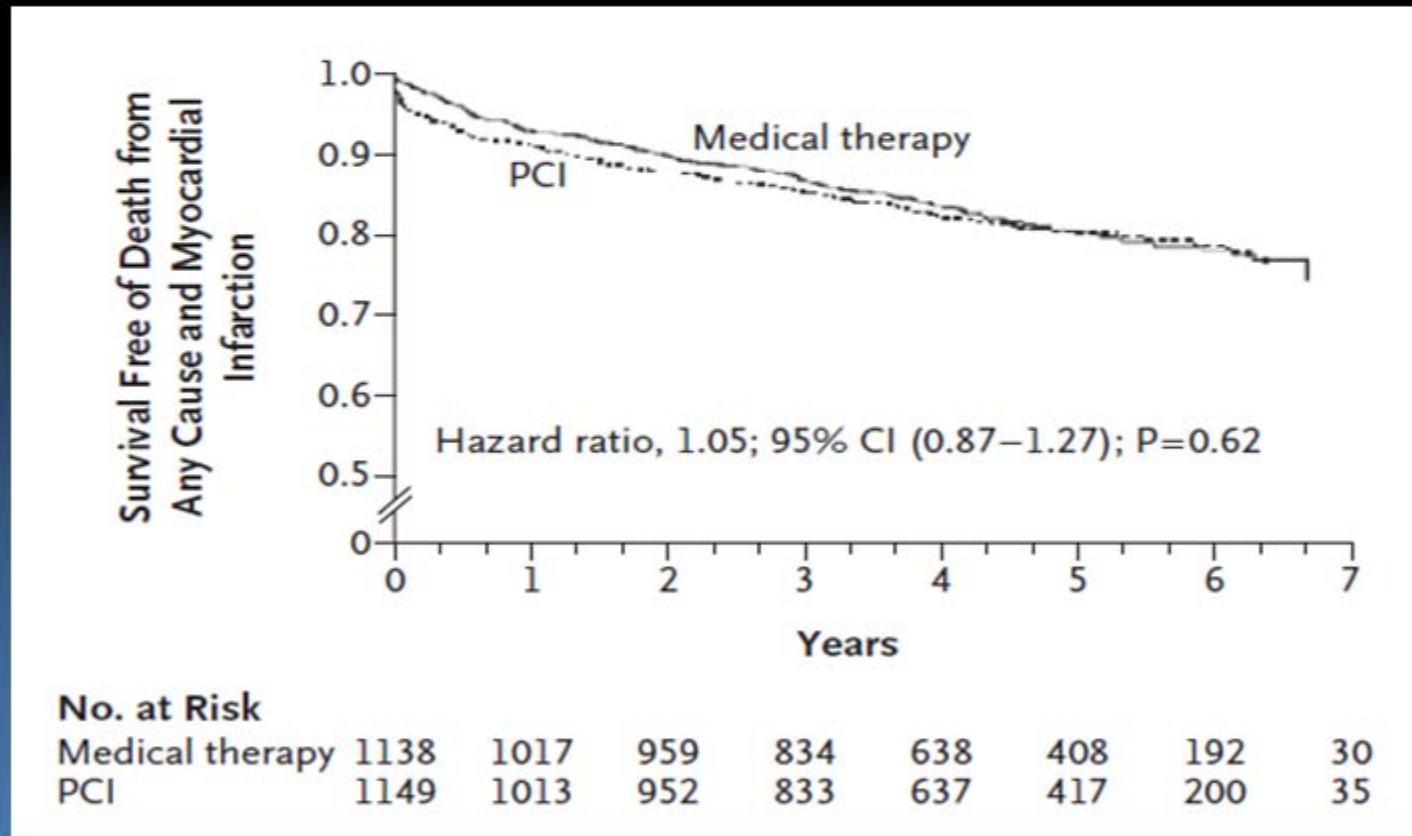
Nuclear Stress Study

CONCLUSIONS:

Multi-slice computed tomographic coronary angiography can definitively establish or exclude coronary disease as the cause of chest pain. **However, inability to determine the physiological significance of intermediate severity coronary lesions and cases with inadequate image quality are present limitations.**

COURAGE Trial

Optimal Medical Therapy with or without PCI for Stable Coronary Disease



Boden WE, et al. for the COURAGE Trial Reserch Group. N Engl J Med 2007; 356: 150-3-16

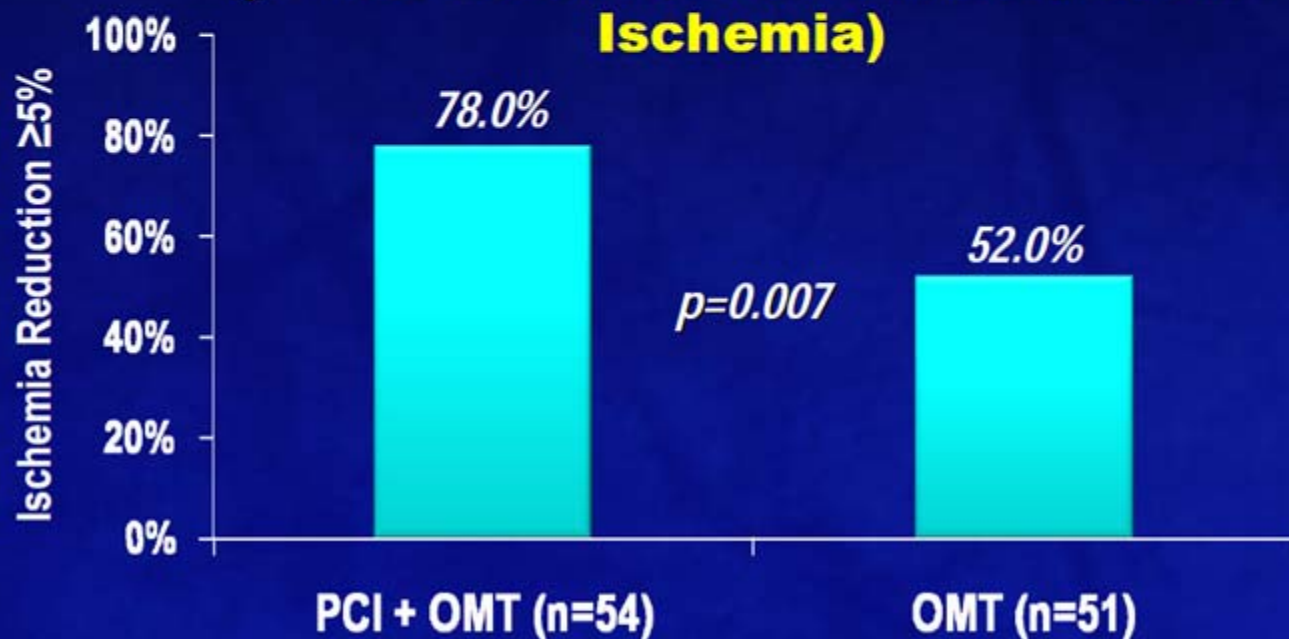
COURAGE Nuclear Substudy II

Optimal Medical Therapy with or without PCI to Reduce Ischemic Burden



**% with Ischemia Reduction $\geq 5\%$
Myocardium**

**(n=105 Moderate-to-Severe Pre-Rx
Ischemia)**

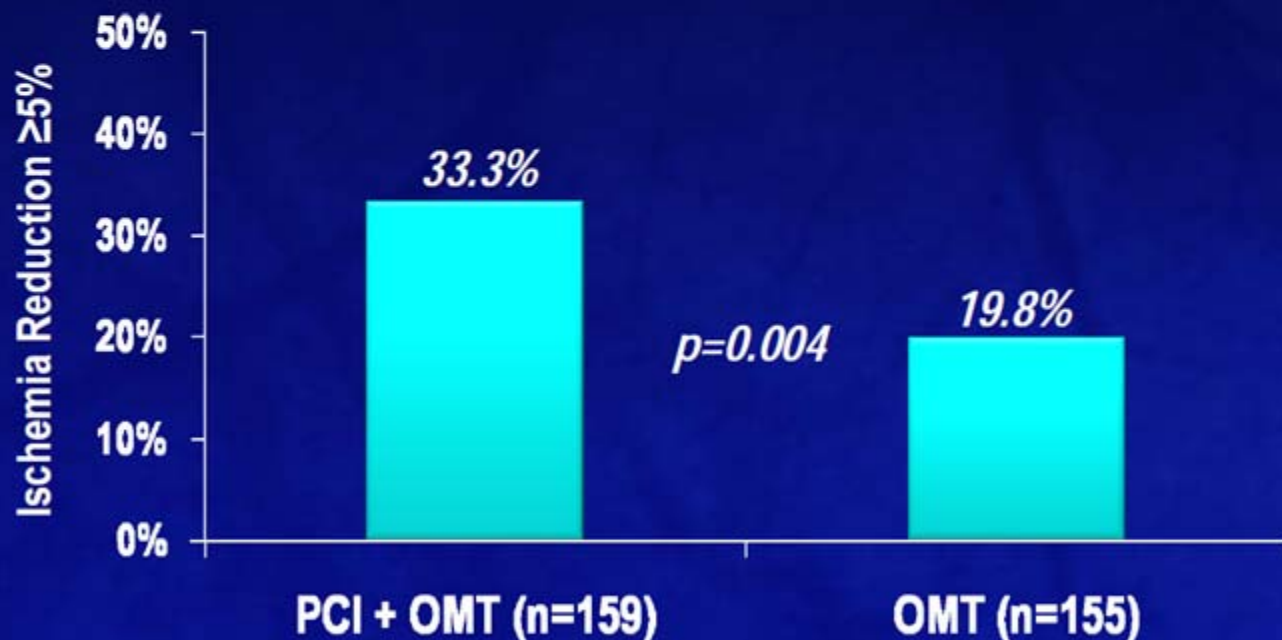


COURAGE Nuclear Substudy II

Optimal Medical Therapy with or without PCI to Reduce Ischemic Burden



Primary Endpoint: % with Ischemia Reduction $\geq 5\%$ Myocardium (N=314)



Integrated Single-Photon Emission Computed Tomography and Computed Tomography Coronary Angiography for the Assessment of Hemodynamically Significant Coronary Artery Lesions

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Ariel Roguin, MD, PhD,§ Adrian Soli,|| Robert Dragu, MD,* Diana Litmanovich, MD,‡
Alex Frenkel, DSc,† Doron Aronson, MD,* Ahuva Engel, MD,‡ Rafael Beyar, MD, DSc, FACC,§
Ora Israel, MD†

Haifa and Tirat HaCarmel, Israel

Objectives	The purpose of this study was to assess the physiologic significance of coronary artery lesions with an integrated single-photon emission computed tomography (SPECT) and computed tomography coronary angiography (CTCA) device.
Background	Myocardial perfusion imaging (MPI) with SPECT is of value for assessing the physiologic significance of coronary lesions. Computed tomography coronary angiography is a new technique to noninvasively detect coronary stenosis, with high sensitivity and negative predictive value (NPV) but lower specificity and positive predictive value (PPV). The experimental SPECT/CTCA hybrid imaging device (Infinia gamma camera and LightSpeed16 CT, General Electric, Milwaukee, Wisconsin) enables concurrent assessment of coronary anatomy and myocardial perfusion.
Methods	Fifty-six patients with angina pectoris underwent single-session SPECT-MPI and CTCA with the hybrid device and coronary angiography (CA) within 4 weeks. The ability of fused SPECT/CTCA images to diagnose physiologically significant lesions showing >50% stenosis and reversible perfusion defects in the same territory was determined and compared with CTCA stand-alone.
Results	Of a total of 224 coronary segments in 56 patients, 12 patients and 54 segments (23%) were excluded from further analysis of CTCA. Overall, 170 coronary segments were evaluated. The sensitivity, specificity, PPV, and NPV of CTCA were 96%, 63%, 31%, and 99%, respectively, as compared with 96%, 95%, 77%, and 99%, respectively, for SPECT/CTCA.
Conclusions	Hybrid SPECT/CTCA imaging results in improved specificity and PPV to detect hemodynamically significant coronary lesions in patients with chest pain. Single-photon emission computed tomography/CTCA might play a potentially important role in the noninvasive diagnosis of coronary artery disease and introduce an objective decision-making tool for assessing the need for interventions in each occluded vessel. (J Am Coll Cardiol 2007; 49:1059-67) © 2007 by the American College of Cardiology Foundation

X-ray coronary angiography (CA), considered the diagnostic standard for establishing the presence of coronary artery stenosis, is limited by its invasive nature and carries small,

nevertheless not negligible, procedure-related mortality (0.15%) and morbidity (1.5%) rates and relatively high cost (1,2). An additional limitation of CA is its inability to define the true extent of atherosclerosis and the presence of eccentric arterial remodeling (3). With only CA it might be often difficult to assess the hemodynamic significance of epicardial narrowing in ambiguous lesions.

See page 1068

Contrast enhanced multidetector computed tomography (CT) offers several advantages over angiography. As a

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Manuscript received June 29, 2006; revised manuscript received August 31, 2006; accepted October 18, 2006.

Table 2

Performance Indexes of CTCA and SPECT/CTCA for Detection of Hemodynamically Significant Coronary Lesions in 170 Segments in 44 Patients

	CTCA	SPECT/CTCA
True positive	24	24
True negative	92	138
False positive	53	7
False negative	1	1
Sensitivity	96%	96%
Specificity	63%	95%*
PPV	31%	77%*
NPV	99%	99%

*p < 0.01 versus computed tomography coronary angiography (CTCA).

NPV = negative predictive value; PPV = positive predictive value; SPECT = single-photon emission computed tomography.

Hybrid SPECT/CTCA imaging results in improved specificity and PPV to detect hemodynamically significant coronary lesions in patients with chest pain.

J Am Coll Cardiol, 2007

Concept of SPECT/CT Fusion Image

心臓MDCT

形態的情報

- ・バイパス評価
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SPECT/CT Fusion Image

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心臓CTで得られる形態的情報に、核医学で得られる機能的情報を加えることで、冠動脈造影を行うことなく狭心症の診断が可能となり、かつ虚血部位の詳細な同定まで可能である。

Concept of SPECT/CT Fusion Image



SPECT
InfiniaHawkeye4(GE)

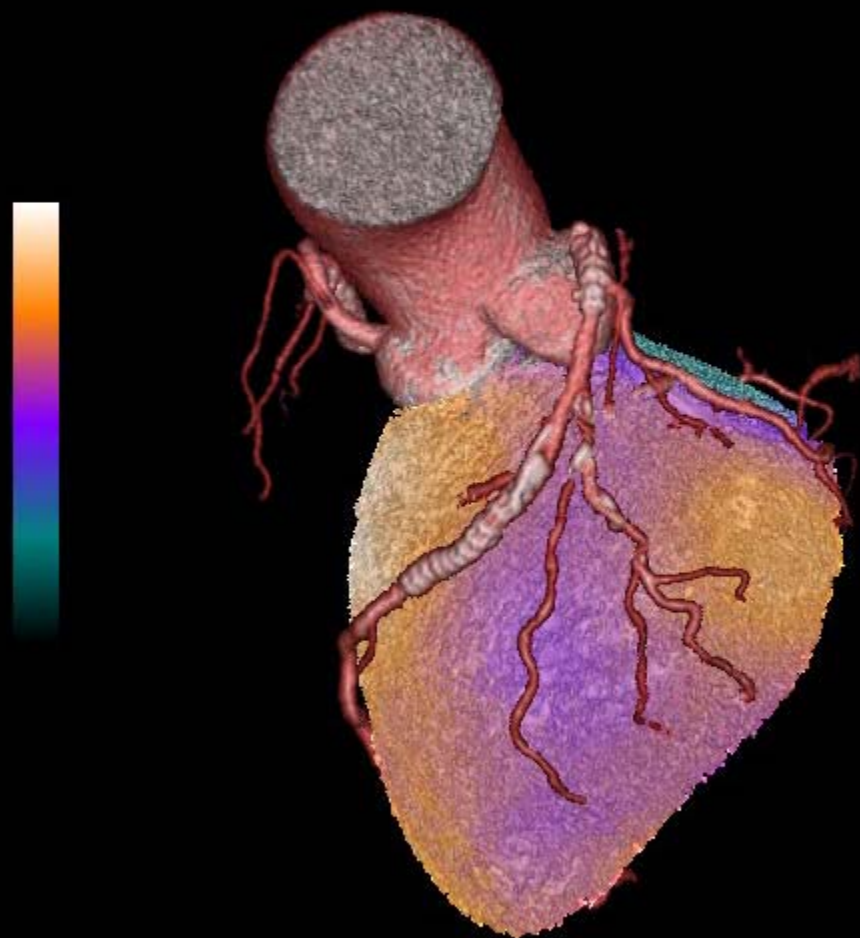


Cardiac CT
LightSpeed VCT(GE)

CardIQ Fusion

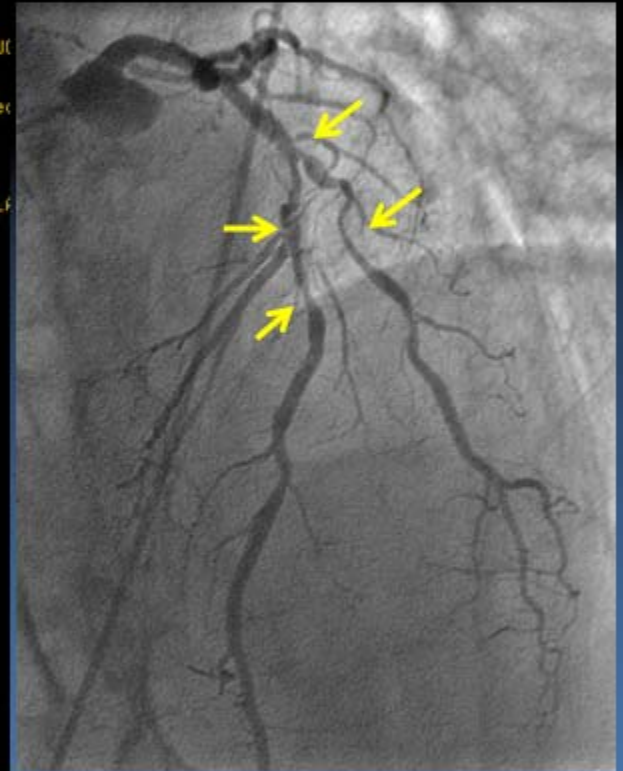
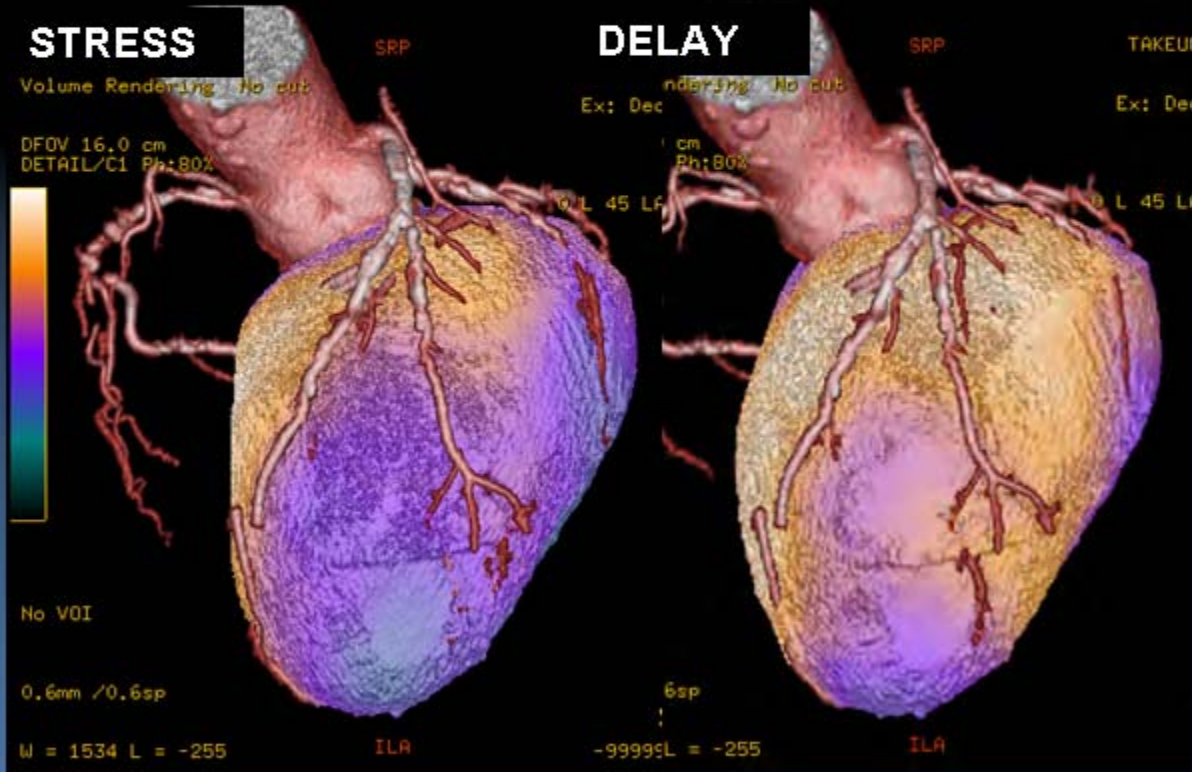
SPECT/CT fusion image

SPECT/CT Fusion Image



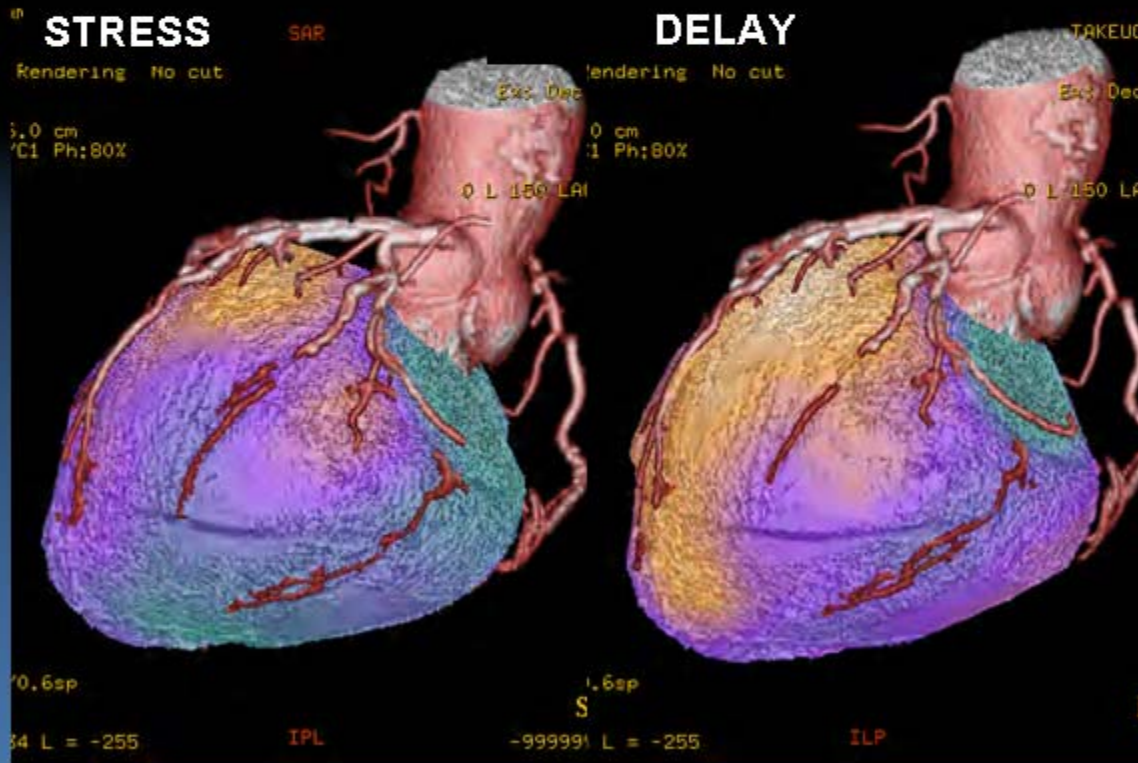
Multi-Vessel Disease

LAD



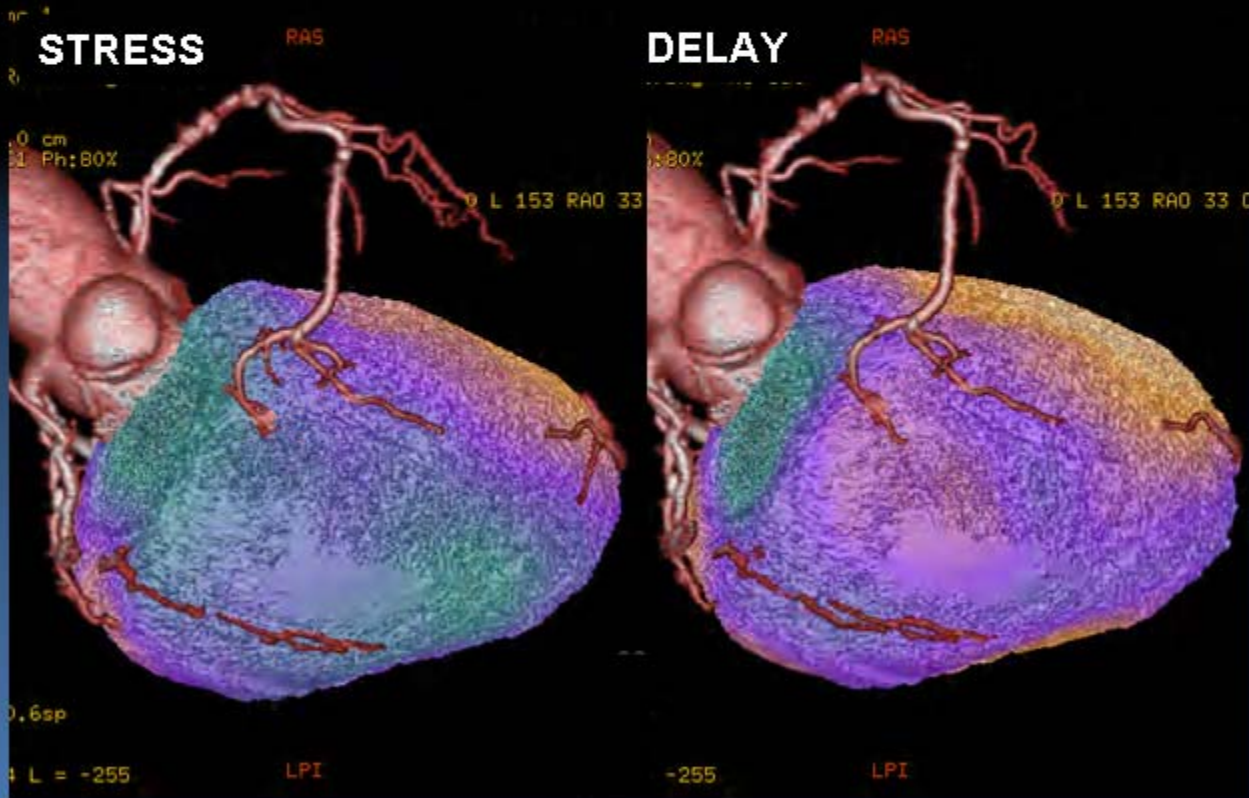
Multi-Vessel Disease

LCx



Multi-Vessel Disease

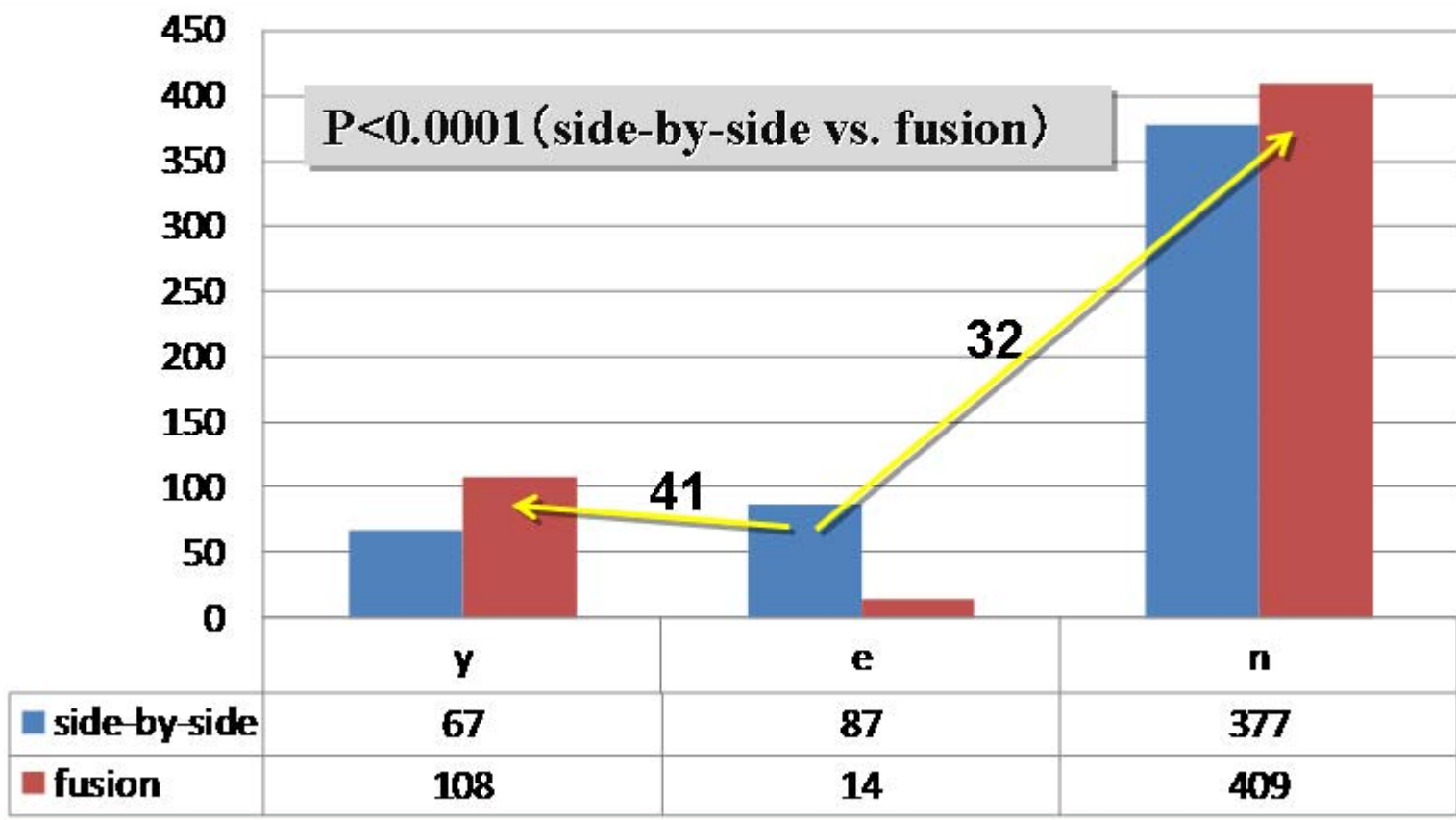
RCA



What is advantageous?

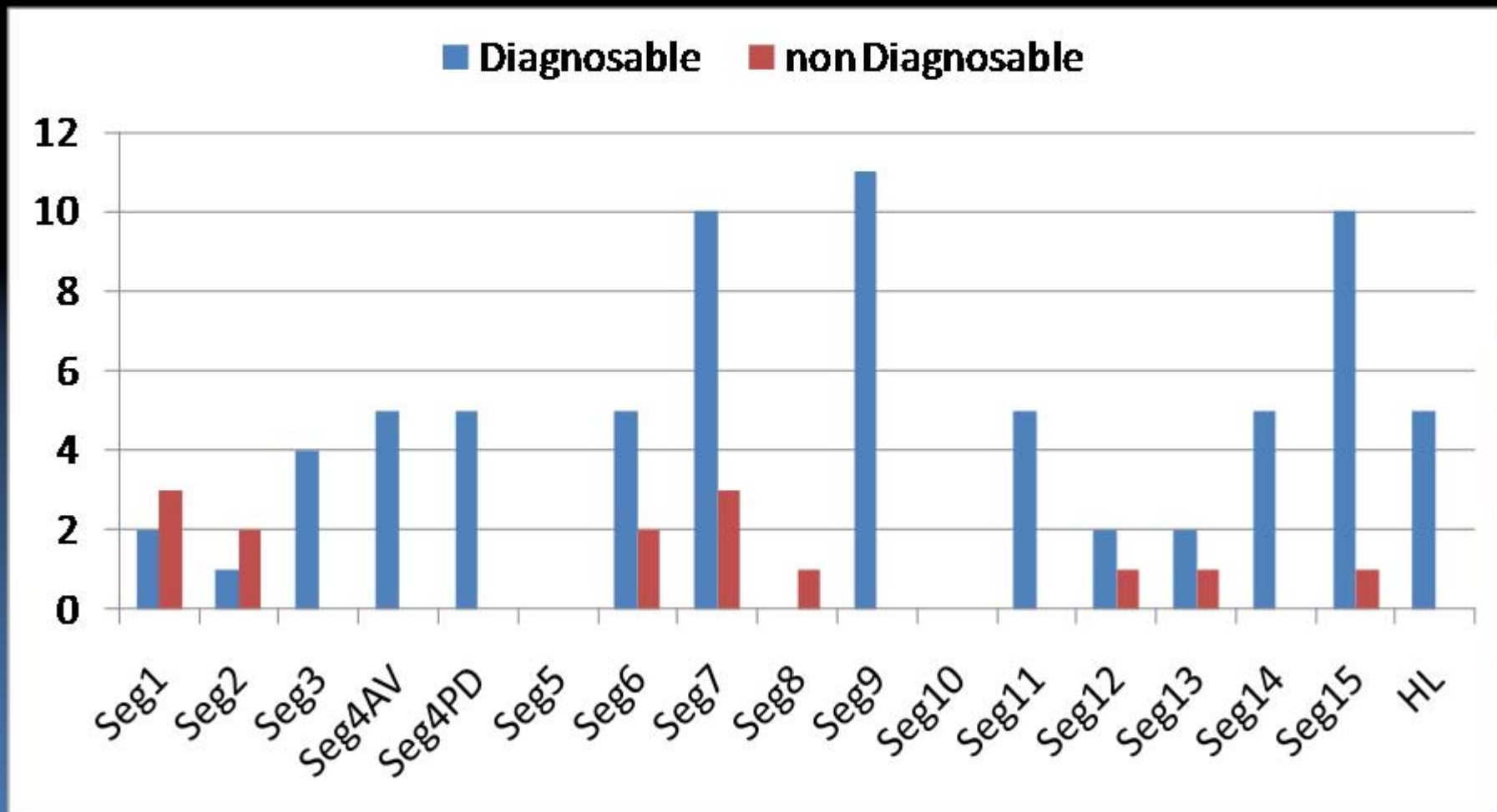
Side-by-side vs. Fusion image

108 patients, 531 Lesions



Goto Y, Kawasaki T, Fukuyama T, et al. JCS 2009

Detail of Equivalent lesion



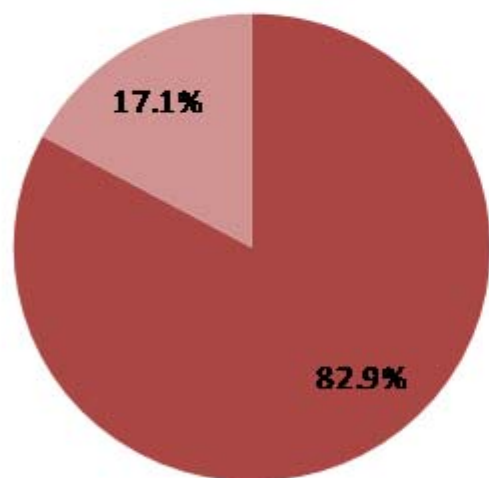
Goto Y, Kawasaki T, Fukuyama T, et al. JCS 2009

Cardiovascular Center, Shin-Koga Hospital

Comparison between Fusion and CAG

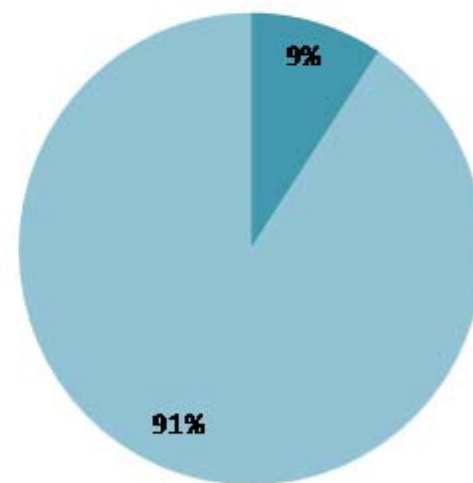
Equivocal → yes(41 lesions)

■ >75% ■ <75%



Equivocal → no(32 lesions)

■ >75% ■ <75%



Sensitivity: 91.9%, PPV: 82.9%

Specificity: 80.6%, NPV: 90.6%

Case Presentation

石灰化による形態的評価の限界

- 症例:67歳 男性
- 主訴:労作時倦怠感
- 冠危険因子
 - 糖尿病
 - 高血圧
 - 高コレステロール血症
- 経過:
 - 2005年糖尿病性腎症で維持透析導入
 - 明らかな胸痛は無いものの、労作時の倦怠感の精査のために心臓MDCTを行い、冠動脈狭窄を指摘され紹介受診となった。

Severe Calcified Lesion

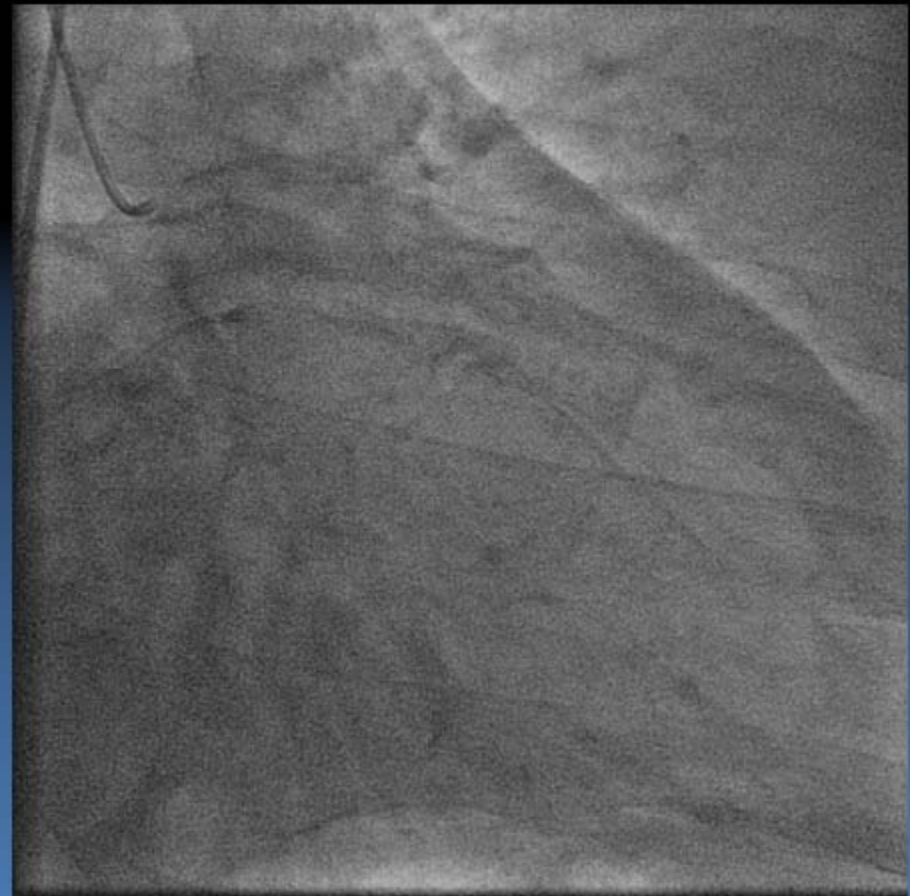


Coronary angiography

RCA



LCA



Case 5: EAP with severe 2VD

Case: 86y/o, female

C.C.: chest oppression on mild effort

Risk factors: DM, HT, HL



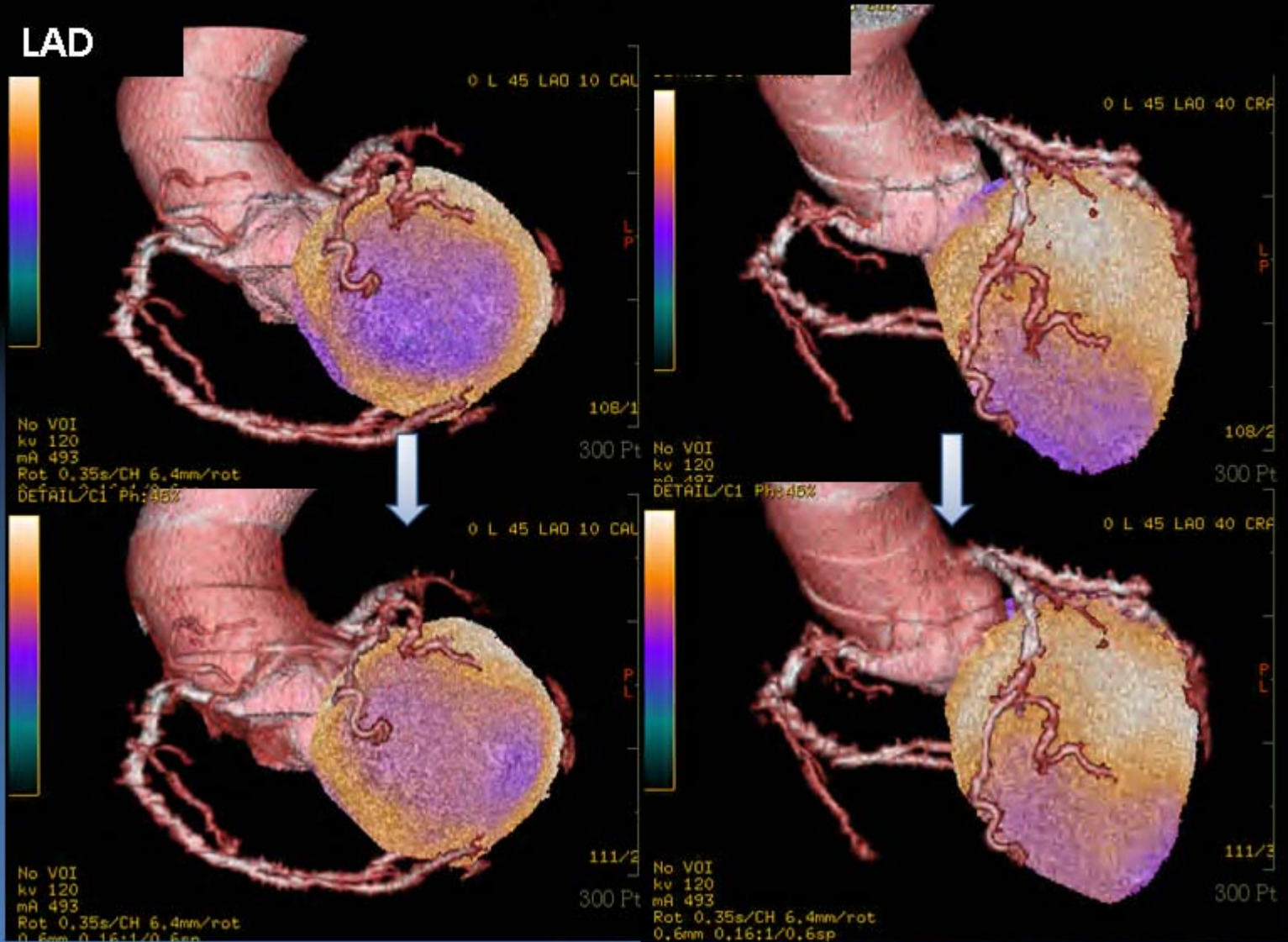
Coronary angiography

Which vessel is more severe, right or left?



Case 5: EAP with severe 2VD

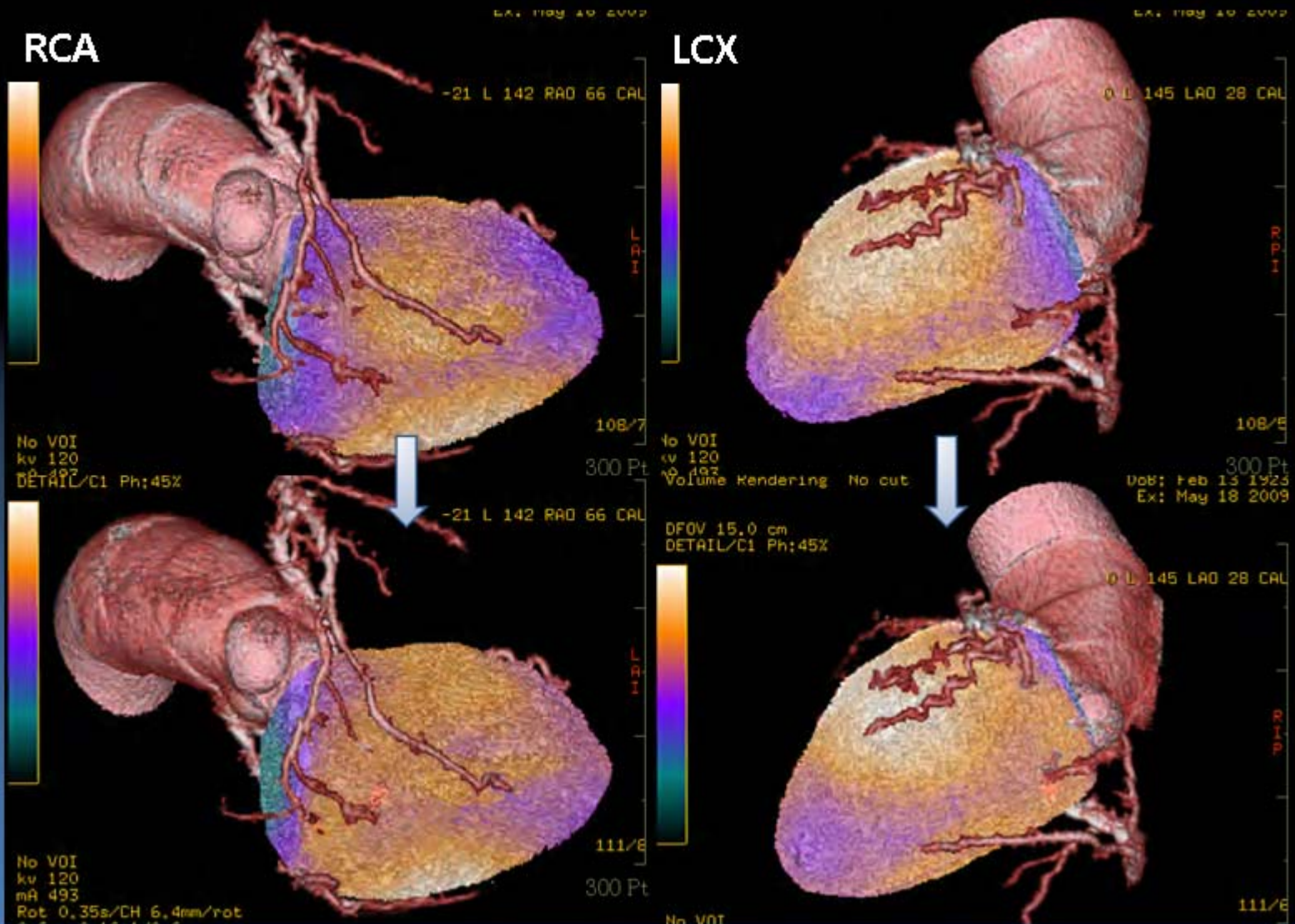
Stress



Delay

Case 5: EAP with severe 2VD

Stress



Delay

Case 5: 1st PCI to RCA

**Her chest pain did not disappear
after RCA PCI !**



Case 5: 2nd Pci to LAD



**Her chest pain disappeared
after LAD PCI.**

症例3:71歳, 女性

【主訴】労作時胸部圧迫感

【冠危険因子】脂質異常症, 高血圧症

【現病歴】

H19年6月seg3:90%に対して2.75mmTAXUS留置.

H20年2月seg15:90%に対してPOBA. その後胸部症状の再燃なし.

今回, 労作時胸部圧迫感あり, 心臓CTではseg6, seg14に狭窄の進行を認め治療予定となった.

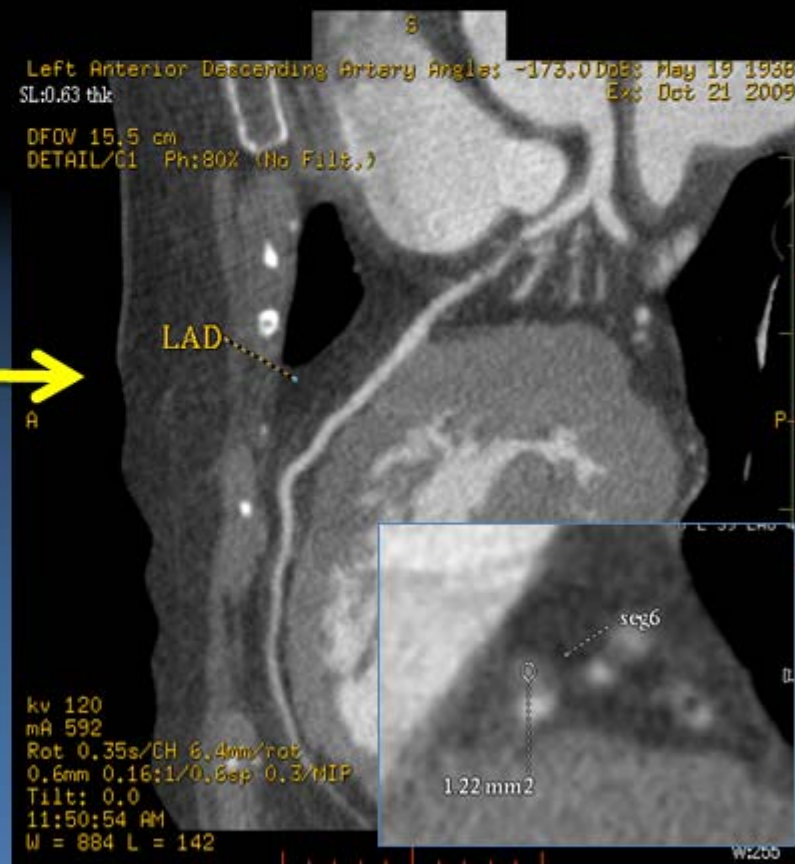
【心電図】洞調律, 有意なST-T変化なし

【心エコー】壁運動異常なし, 器質的心疾患なし

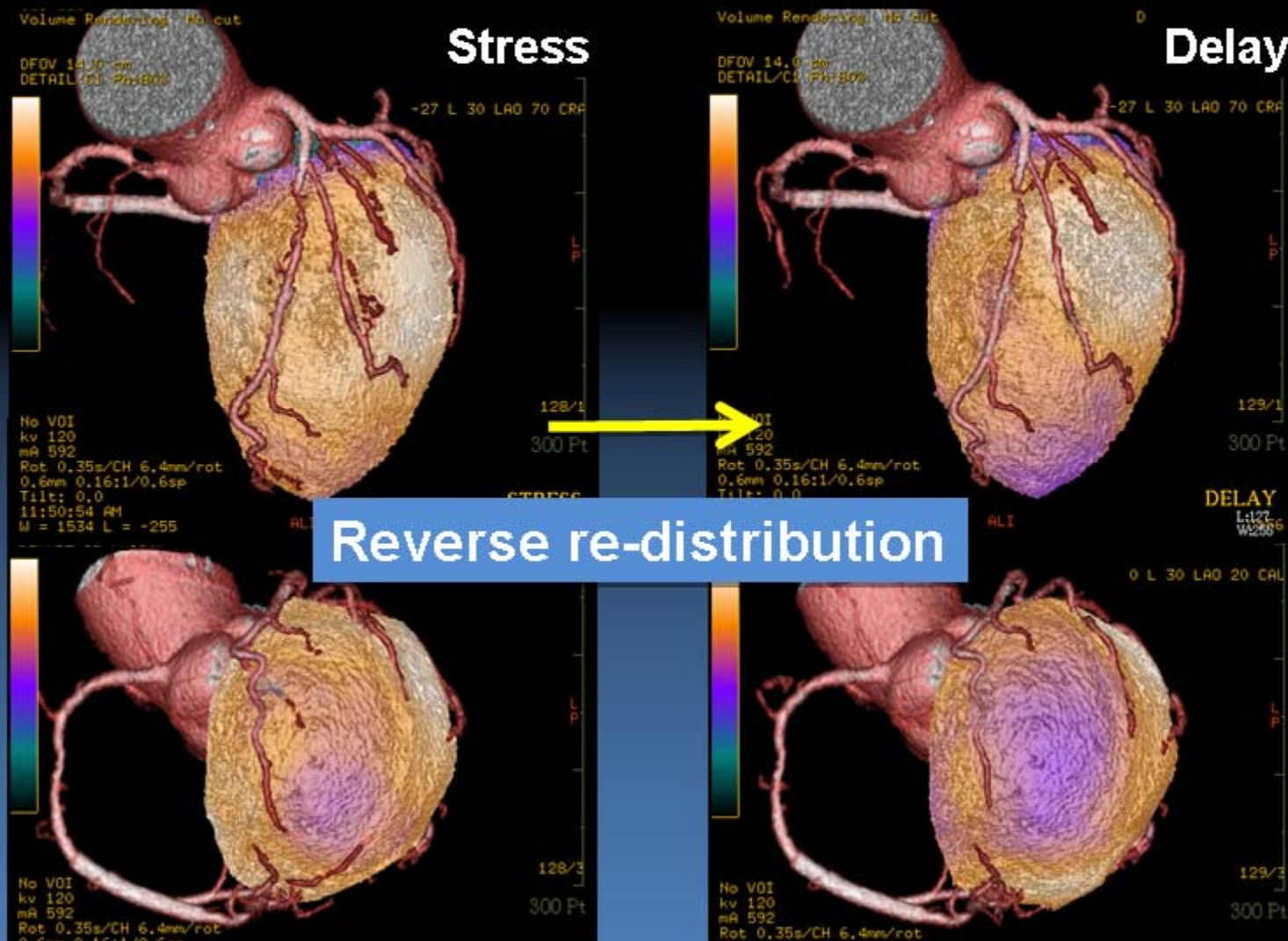
【CTA】seg6:高度狭窄, seg14高度狭窄

【SPECT-MPI】LAD領域に逆再分布現象を認めている.

病例3: 71歲, 女性

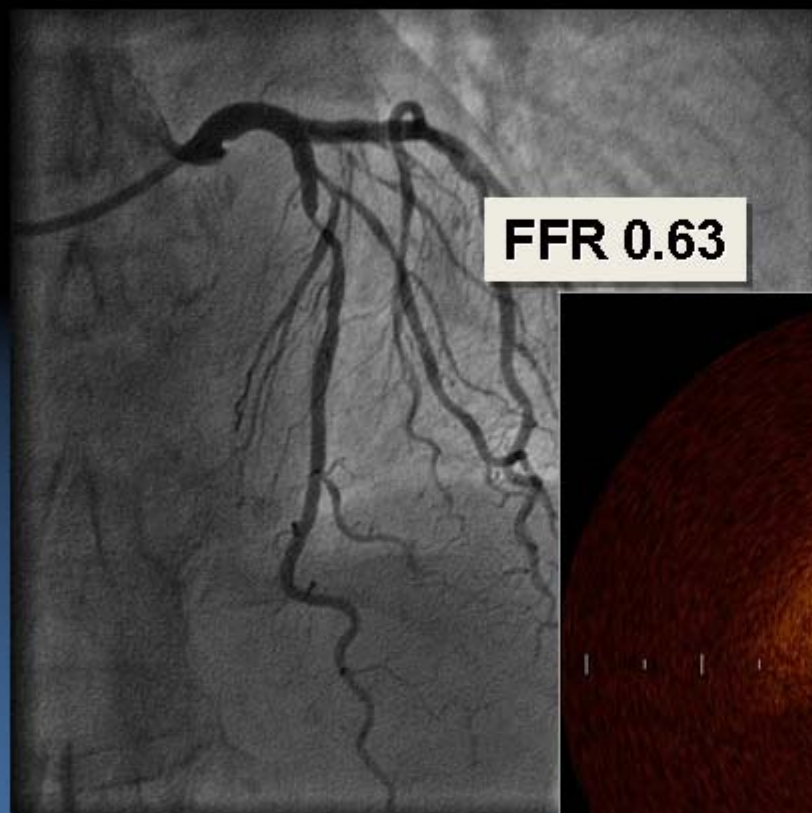


症例3:71歳, 女性



症例3:71歳, 女性

CVIT 地方会ライブ



総括

- 心臓CTはそのパフォーマンスの高さと情報量の多さから、従来からの冠動脈造影検査に取って代われる画像診断方法であると考えられる。
- SPECT/CT fusion imagingは、心臓CTを用いた形態的評価にMPSを用いた機能的評価を加えることで、多枝病変においても病変枝別の虚血診断を正確に行うことができ、治療を必要とする病変の診断率は有意に向上する。
- 心臓CTによる形態的評価全盛となりつつある現在、機能的評価を合わせ行うことは重要な意味を持つ。
- SPECT/CT fusion imagingはその両者を一元的に把握・表示可能であり、このfusion imagingを十分に活用することで、より良質な評価・治療が可能となるのではないかと考える。