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Simplified Bernoulli Method to Diagnose Functional Ischemia by Coronary CTA: Comparison with SPECT

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Background

- Importance of PCI with evidence of ischemia is important to improve the patient outcome.
- FFRCT is an FDA approved method to assess ischemia using coronary CTA data but additional cost is necessary.
- Pressure loss across coronary stenosis could be easily estimated using ***simplified Bernoulli formula***.

Estimating Pressure Loss

Braunwald's Heart Disease. Elsevier 2004
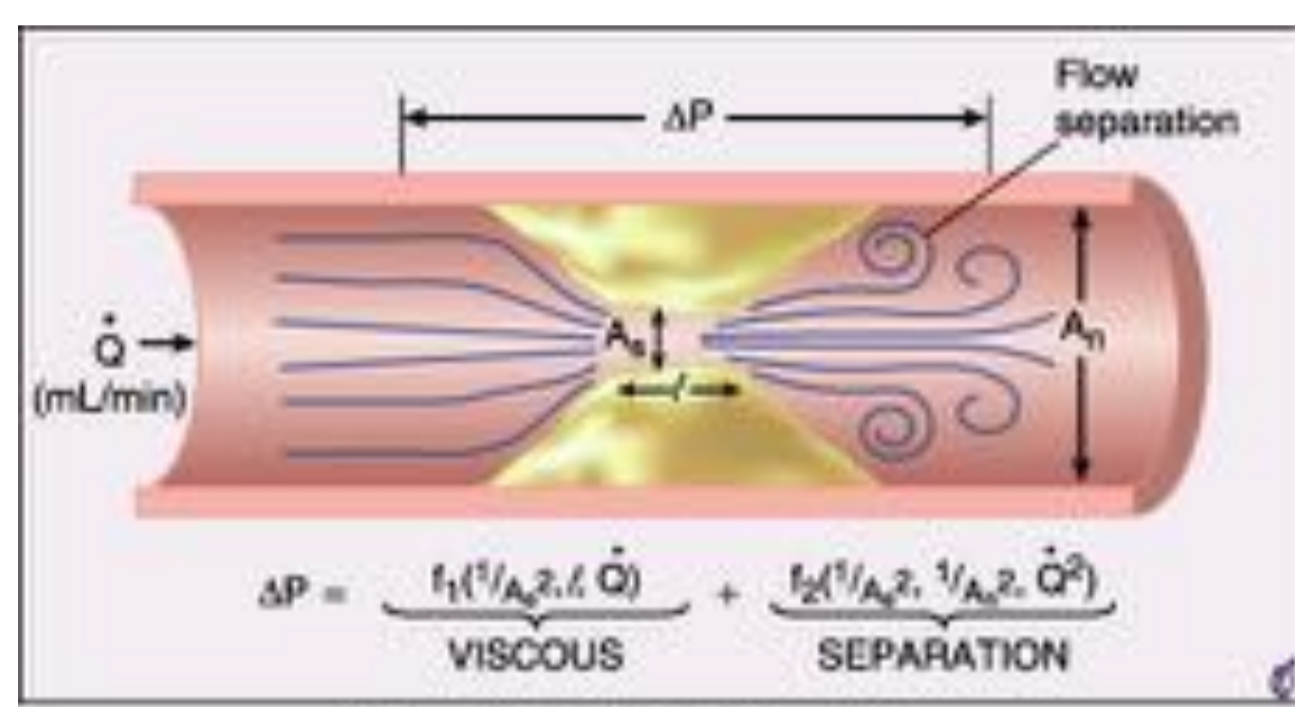
Simplified Bernoulli Formula

Consists of two terms:
- 1st term   Viscous friction
- 2nd term   Turbulent non-laminar distal flow

$$\Delta P = Q\,\frac{8\pi\mu LL}{MLA^2} + Q^2\,\frac{\rho}{2}\,\frac{(1-(1-DS/100)^2)^2}{MLA^2}$$

Definition of estimated energy loss (EEL)

$$EEL = \log(\Delta P)$$

Parameters needed for calculation:
- LL   lesion length
- MLA minimal lumen area
- DS   diameter stenosis
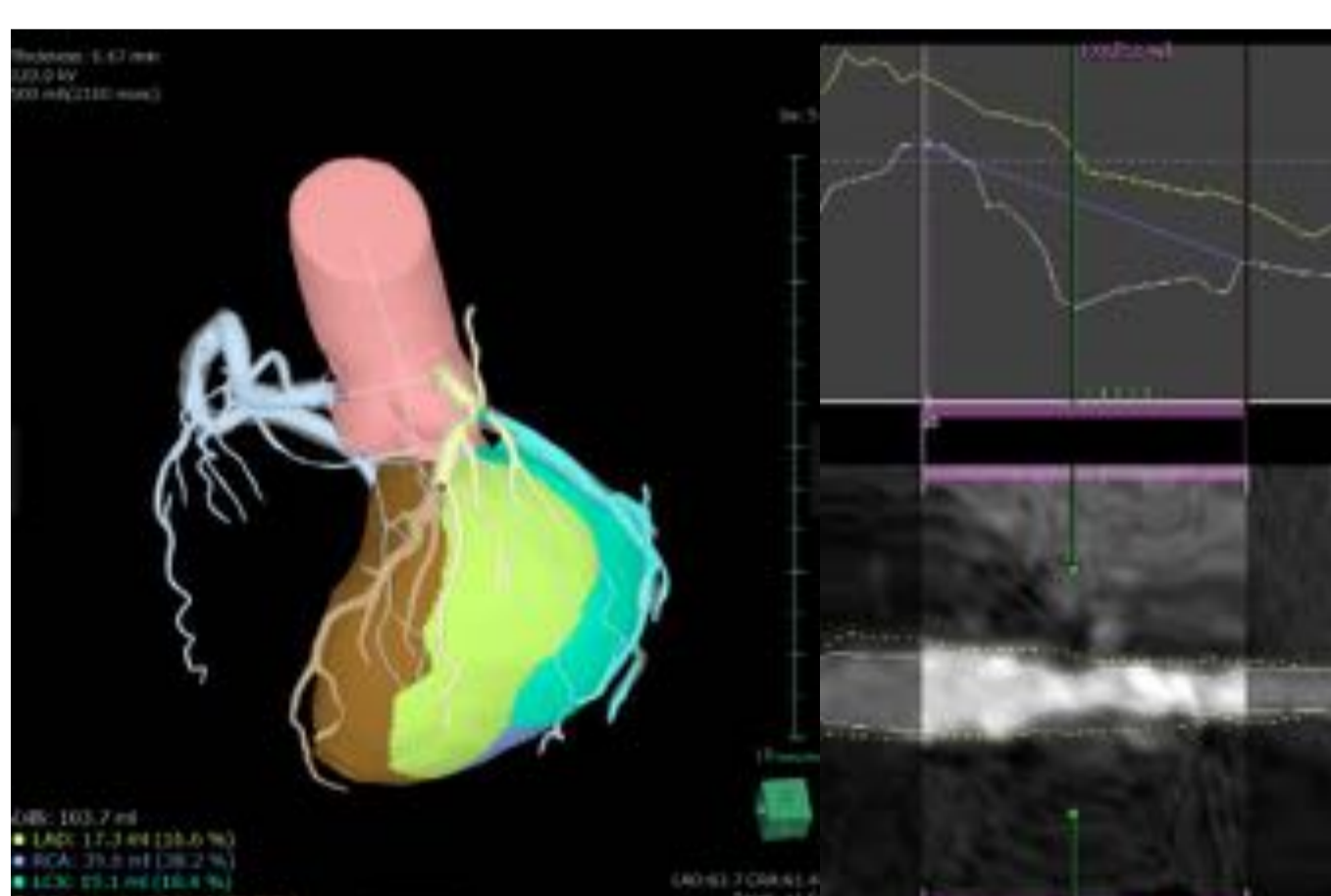- Q   coronary flow at hyperemia

Objective

To compare the diagnostic performance of EEL and SPECT to predict FFR positive stenosis by cath.

Methods

Patients

A total of 43 patients suspected of IHD by coronary CTA who underwent both SPECT and invasive FFR were retrospectively included.
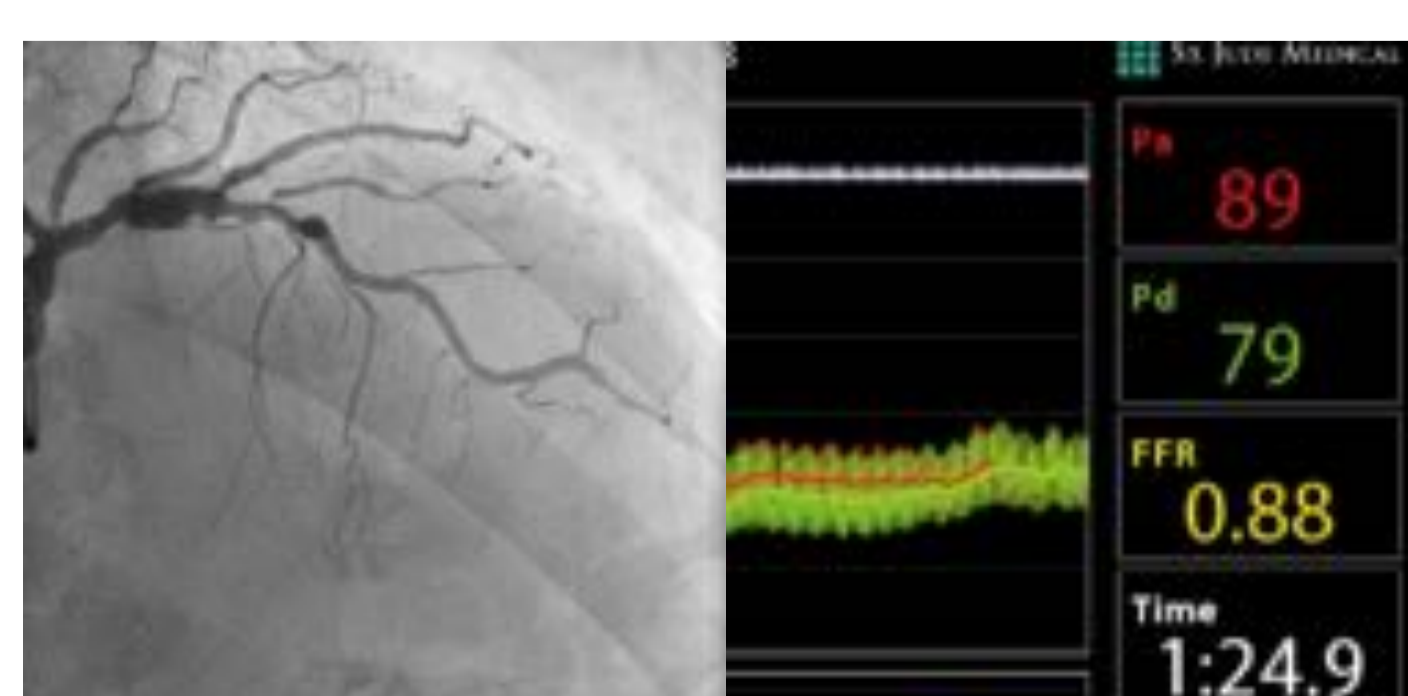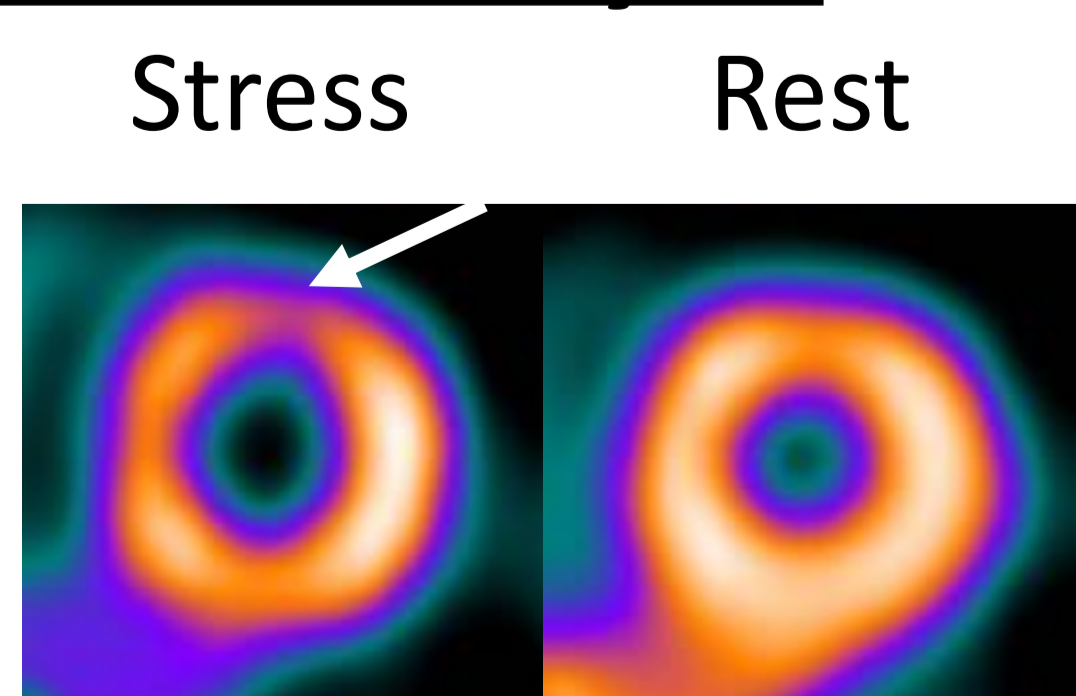
CTA analysis

LL, DS, MLA were acquired by using a software (VINCENT ver 5.2; Fujifilm Medical, Tokyo, Japan). **Voronoi method** was used to estimate the myocardial volume of the stenotic territory.
The flow at hyperemia was estimated as **4.0 ml/min/g**.

SPECT analysis

Stress   Rest

FFR analysis

Criteria for ischemia
EEL>1.17; fill-in at SPECT; FFR ≤0.80

Results

Patient Demographics

Number	43	Disease severity	
Male / female	32 / 11	1 vessel disease	11 (26)
Age (y)	73.6±6.6	2 vessel disease	6 (14)
Body weight (kg)	60.6±11.1	3 vessel disease	1 (2)
BMI (kg/m²)	23.1±2.6	Disease location	
Risk factor		RCA	3 (7)
Diabetes	12 (28)	LAD	14 (33)
Hypertension	36 (84)	LCX	1 (2)
Dyslipidemia	29 (67)		
Smoking	31 (72)		
Family history	11 (26)		
Calcium score	468.7 (142.5–848.7)		

FFR positive
26 out of 127 vessels (20%)

EEL vs SPECT: ROC Curve & Diagnostic Performance

p <0.005
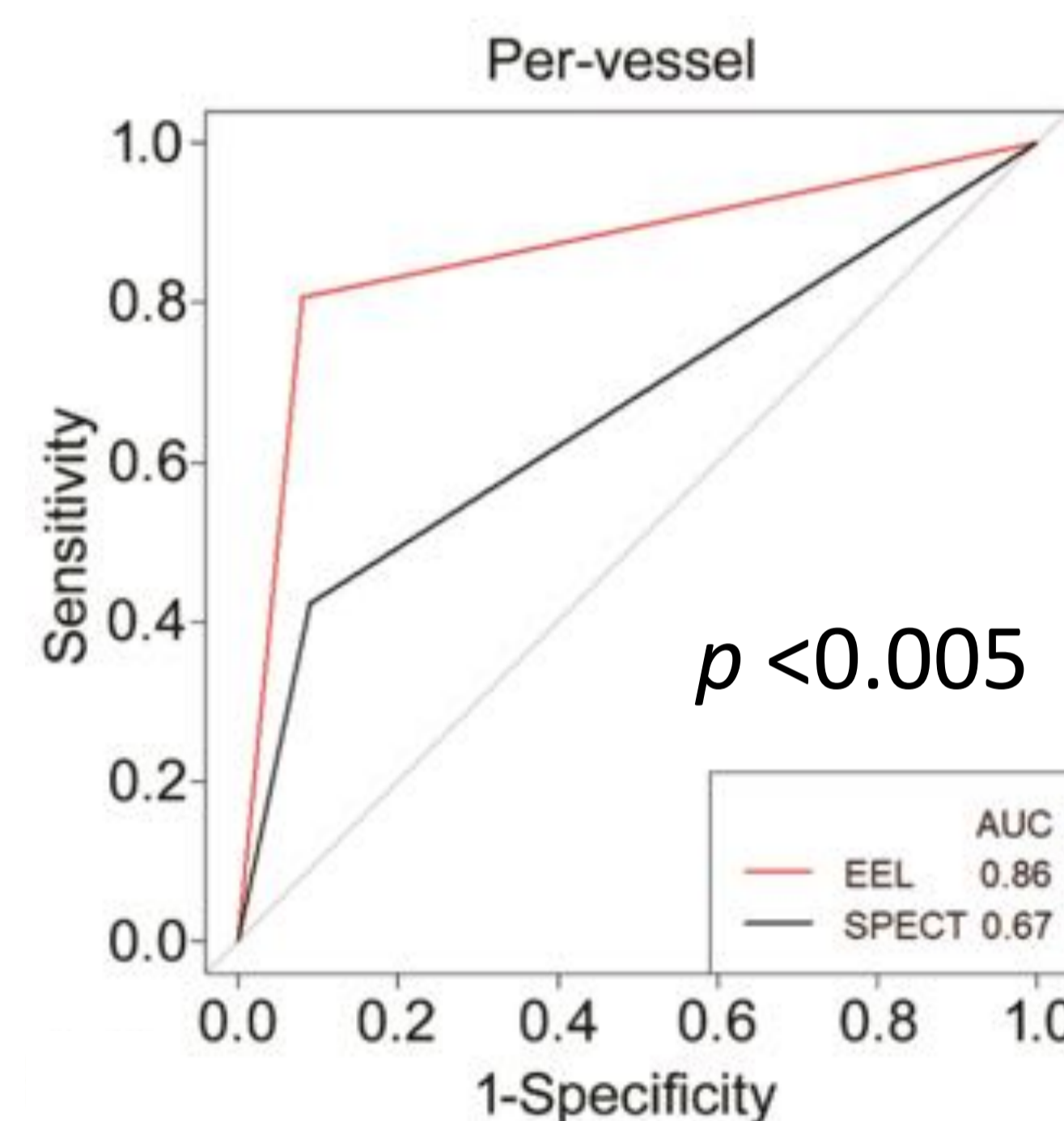
Per-vessel	EEL	SPECT
Accuracy	90 (83–94)	81 (73–88)
Sensitivity	81 (61–93)	42 (23–63)
Specificity	92 (85–97)	91 (84–96)
PPV	72 (53–87)	55 (32–77)
NPV	95 (89–98)	86 (78–92)

EEL significantly (p <0.05) **improved the accuracy** to diagnose FFR positive stenosis.

Case: 70 y M with Effort Angina
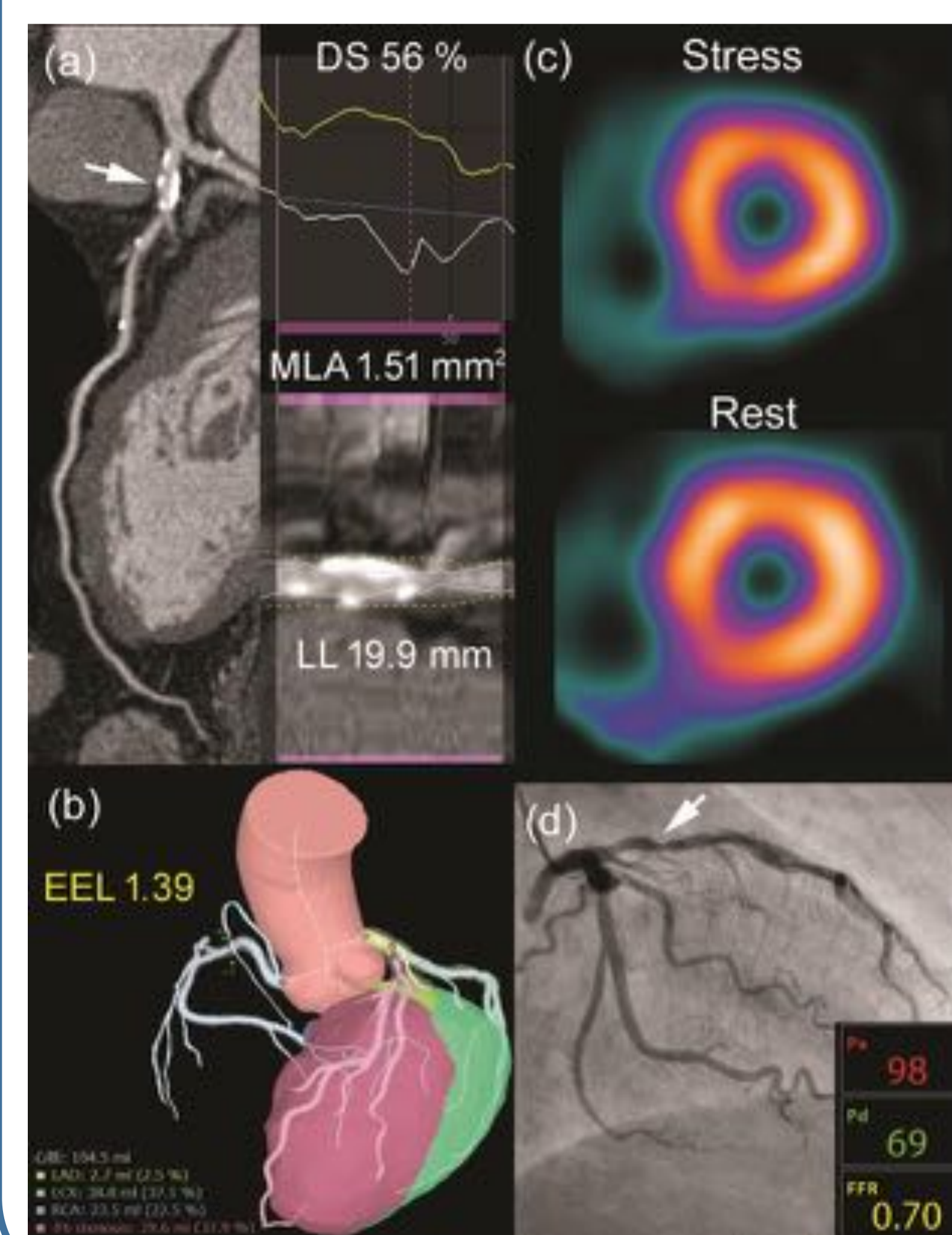
EEL	*Ischemic* 1.39 (>1.17)
SPECT	*Non-ischemic*
FFR	*Ischemic* 0.70 (≤0.80)

EEL *TP*
SPECT *FN*

(a) CPR of LAD, (b) myocardial mass analysis, (c) SPECT, (d) cath FFR

Summary & Conclusion

➢ EEL improved the diagnostic performance of coronary CT to detect ischemic stenosis compared with SPECT.
➢ The accuracy of EEL was 90%.
➢ EEL outperformed SPECT in sensitivity.
➢ ***EEL would enable to assess ischemia on-site very easily without spending time!***

Conflict of Interest
The authors have no conflict of interest to disclose.