



Angio-based microcirculation evaluation

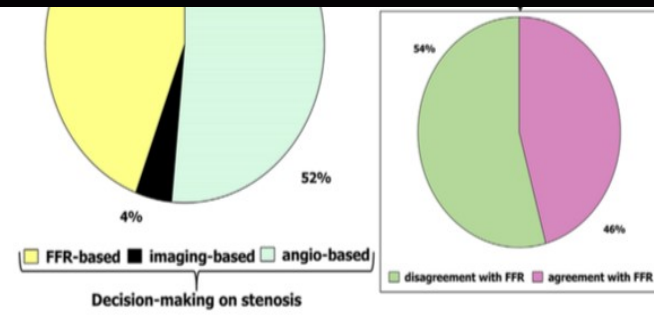
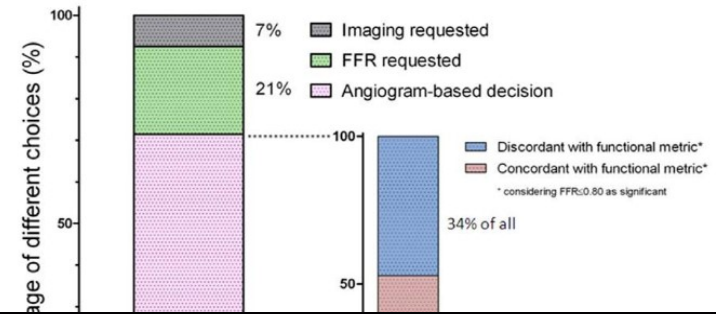
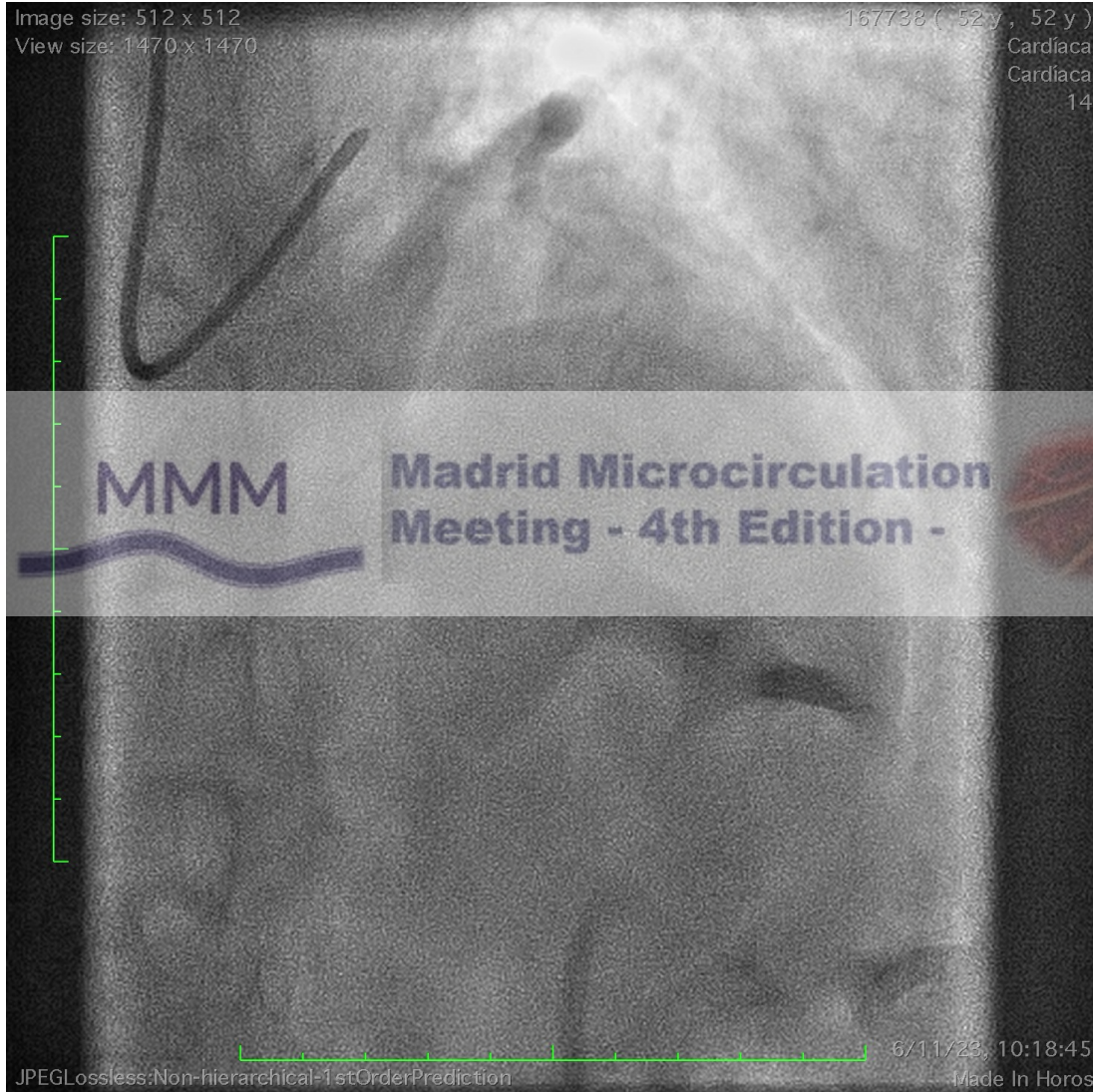
Dr. Carlos Cortés



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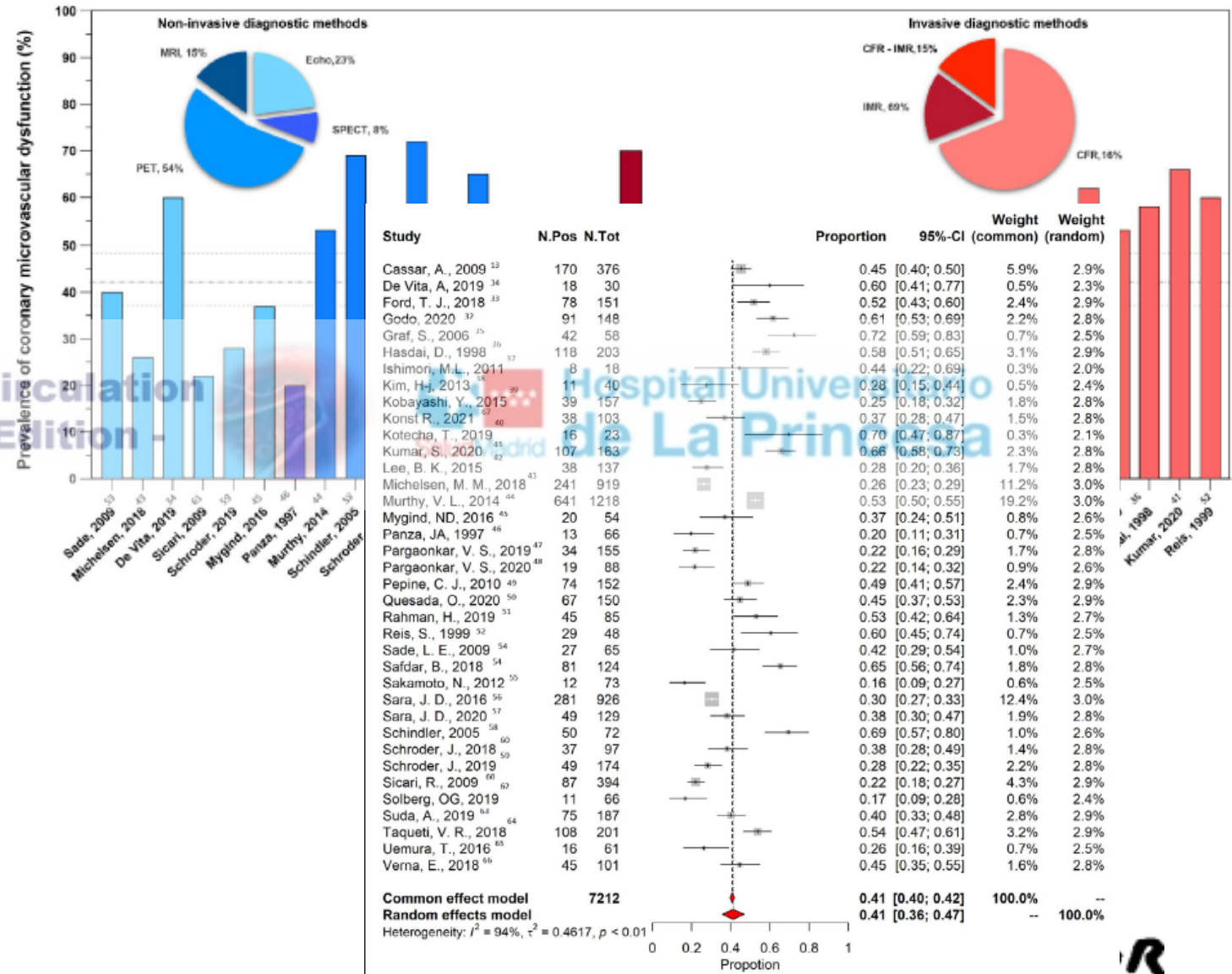
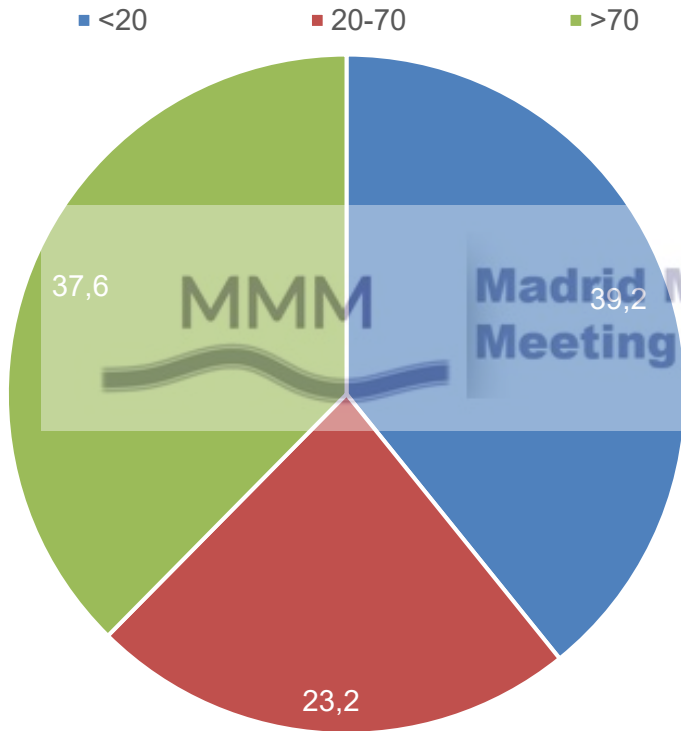


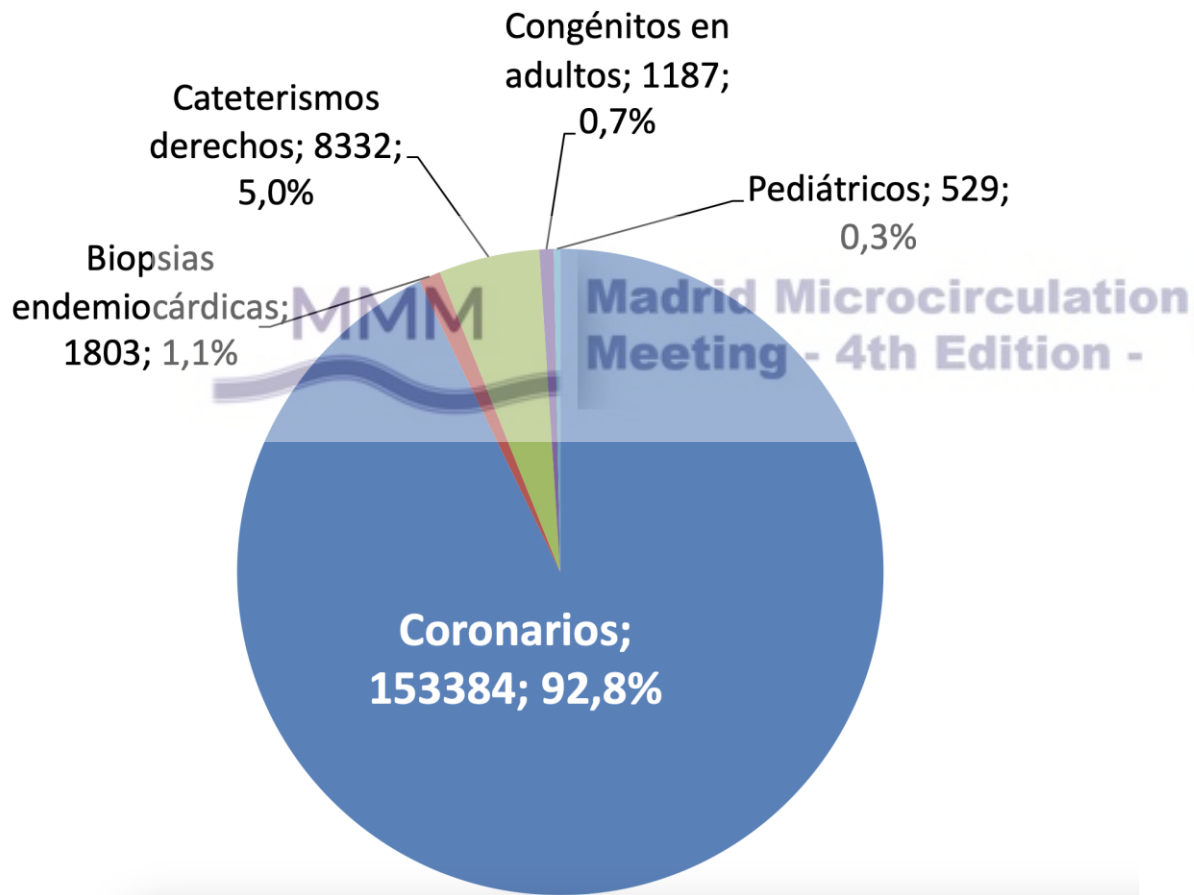
Introduction



Prevalence of CMD

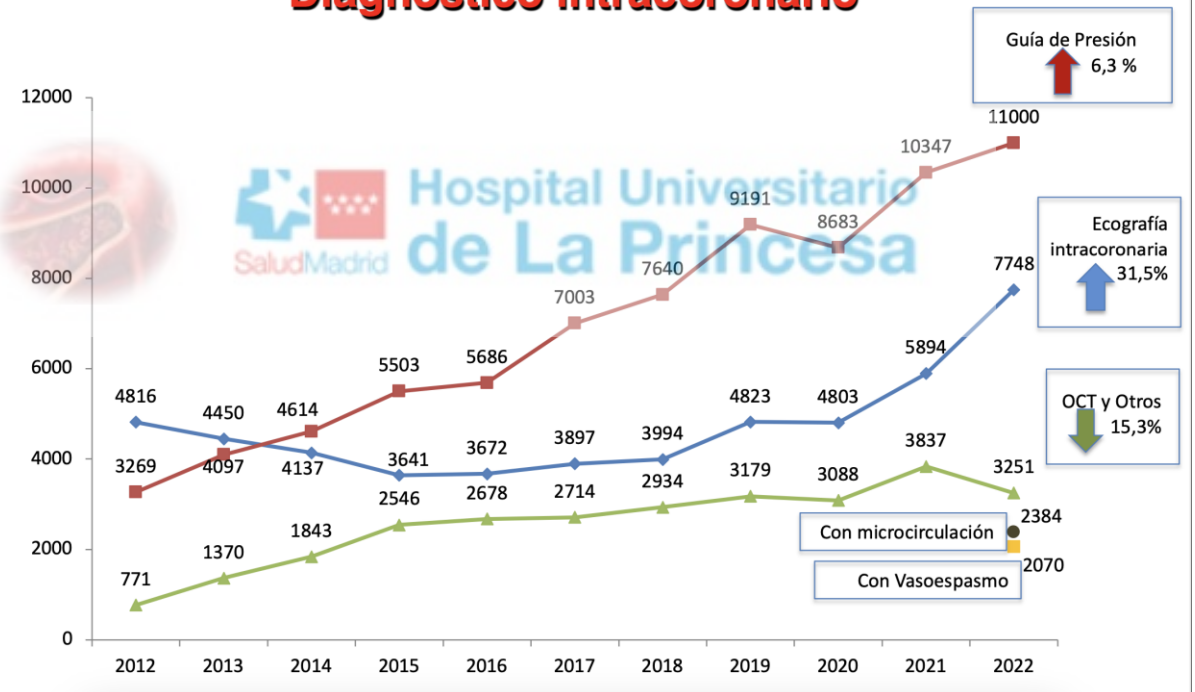
% Diameter Stenosis





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Diagnóstico intracoronario



Angio based FFR

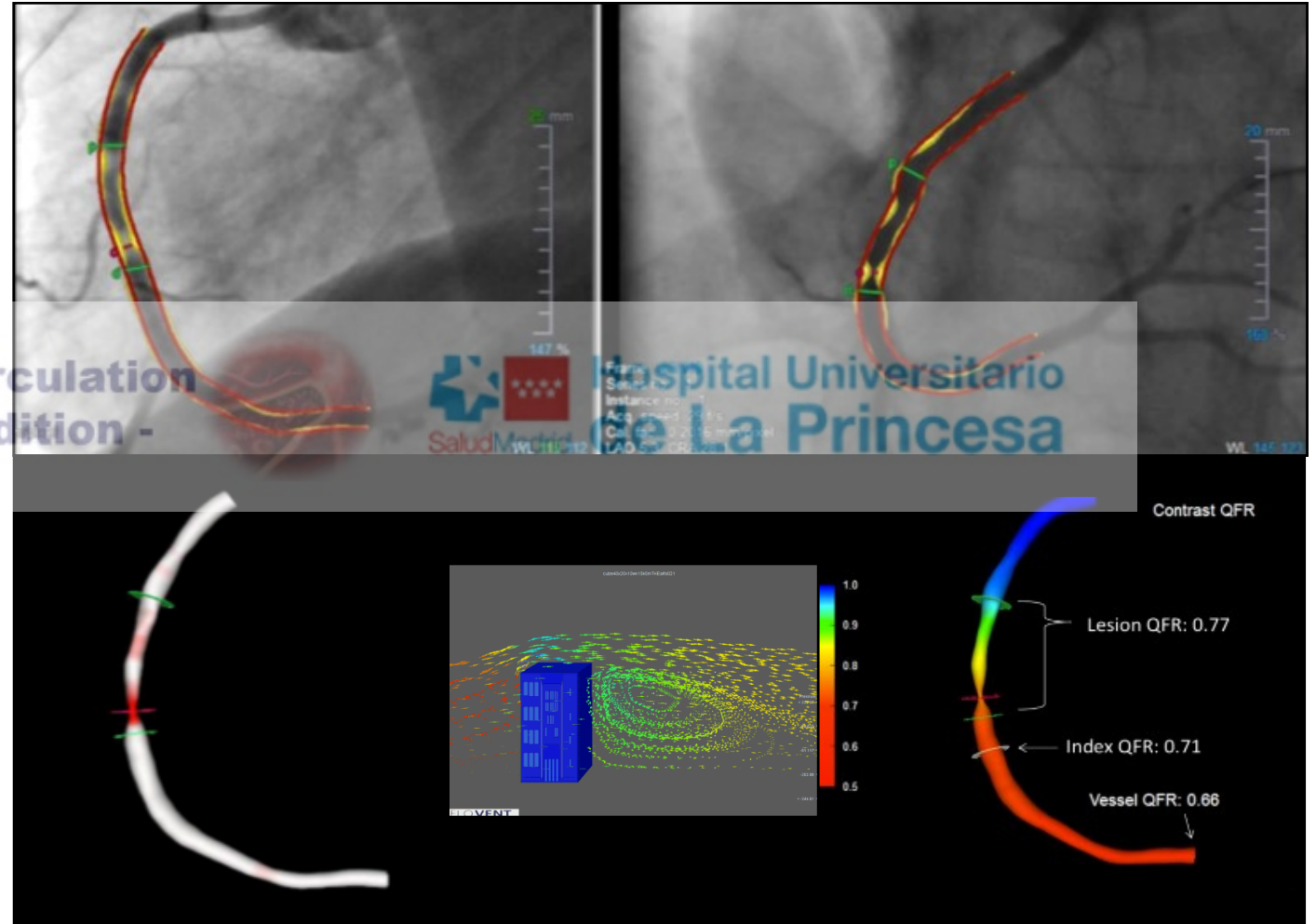
ANGIO BASED FFR

TABLE 2 Operator Rationale for Not Performing a Physiology Assessment When Indicated

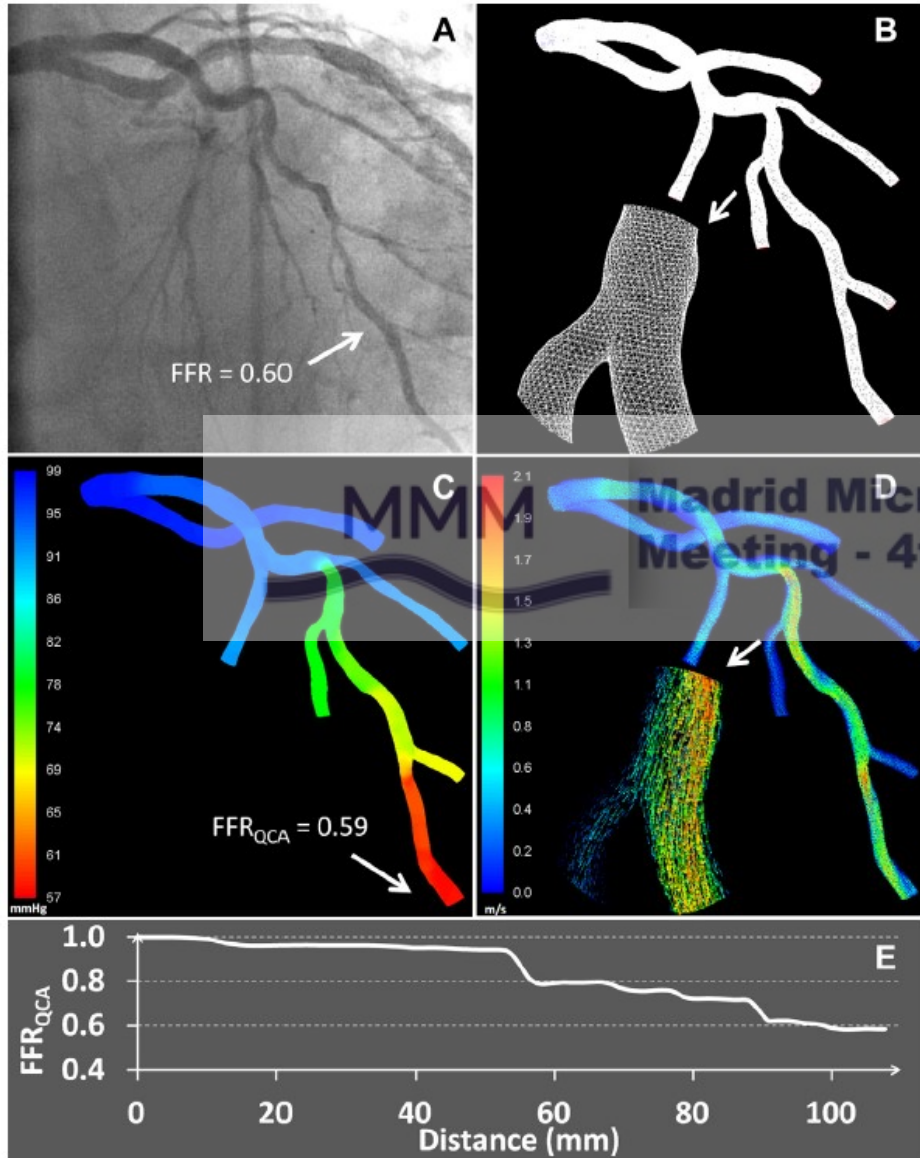
Attitudes (lack of agreement and inertia of previous practice)	
Clinical and angiographic data are sufficient	455 (39.3)
Certainly significant lesion	223
Certainly not significant lesion	164
FFR/IFR does not improve my ability to stratify lesions	68
I prefer to achieve a complete revascularization	102 (8.8)
Co-culprit lesion in a patient with ACS	67 (5.7)
I will monitor the patient's symptoms during follow-up	56 (4.5)
Knowledge (lack of awareness and familiarity)	
FFR/IFR not feasible (e.g., wire does not cross the lesion and myocardial bridge)	129 (11.1)
Lesion >50% in the proximal LAD or left main coronary artery	120 (10.3)
Intracoronary imaging (IVUS/OCT) is better	82 (7.5)
Stratification in the follow-up with stress test	40 (3.4)
Behavior (external barriers)	
Time constraint	47 (4.1)
Adenosine side effects or cost	30 (2.6)
Costs	28 (2.5)

Values are n (%) or n.

ACS = acute coronary syndrome(s); IVUS = intravascular ultrasonography; LAD = left anterior descending coronary artery; OCT = optical coherence tomography; other abbreviations as in Table 1.



AngioFFR computation



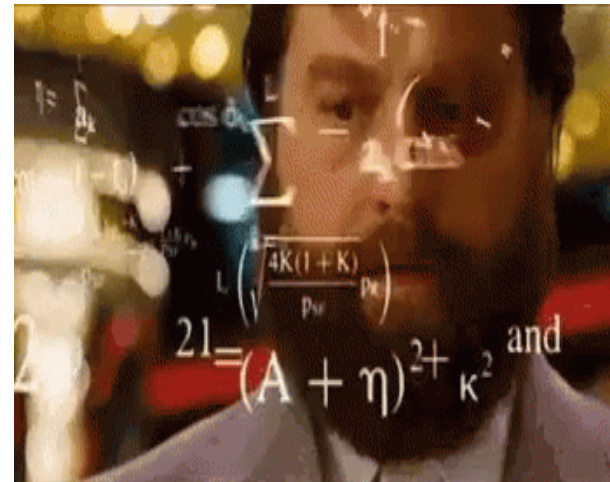
The pressure drop ΔP for each subsegment of coronary reconstruction was calculated using:

- the stenosis geometry
- mean hyperemic flow velocity (HFV):

$$\Delta P = c_1 * HFV + c_2 * HFV^2$$

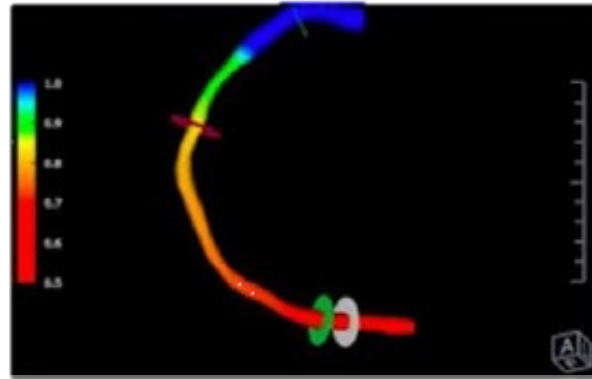
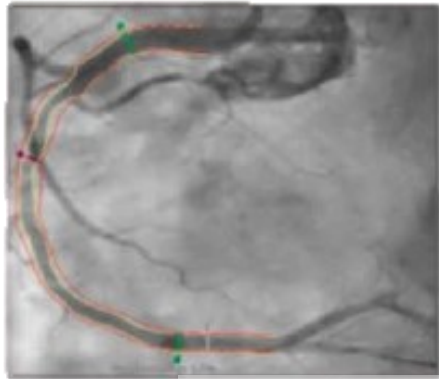
$$HFV = a_0 + a_1 * CFV + a_2 * CFV^2$$

$$\text{AngioFFR} = (P_a - \int \Delta P \, dx) / P_a$$



QFR computation

	QFR		μ FR	vFFR	FFR angio	caFFR
	FAVOR II China	FAVOR II Europa-Japón	Tu, S	FAST II Corelab ⁹	FAST-FFR ²	Flash I
Trial Design						
Year Published	2017	2018	2021	2021	2018	2019
N Patients	308	317	306	334	301	323
N Vessels	328	317	330	334	319	323
Diagnostic Performance Compared to FFR						
Sensitivity	94.6%	86.5%	87.5%	81%	93.5%	90.4%
Specificity	91.7%	86.9%	96.4%	95%	91.2%	98.6%
Accuracy	92.4%	86.8%	93.0%	90%	92.2%	95.7%
Positive Predictive Value	85.5%	76.3%	92.9%	90%	89.0%	97.2%
Negative Predictive Value	97.1%	93.0%	93.1%	90%	94.8%	95.0%

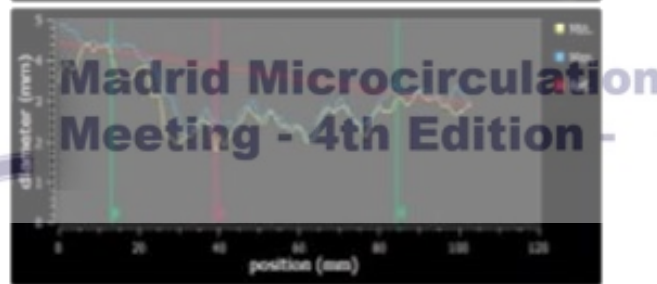
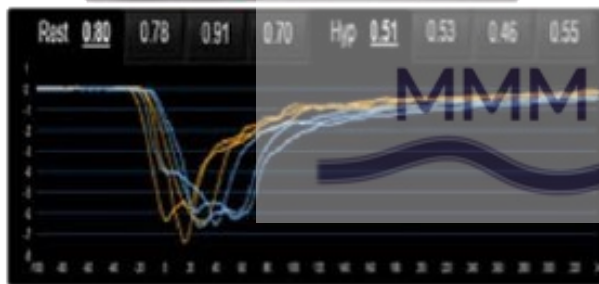


IMR

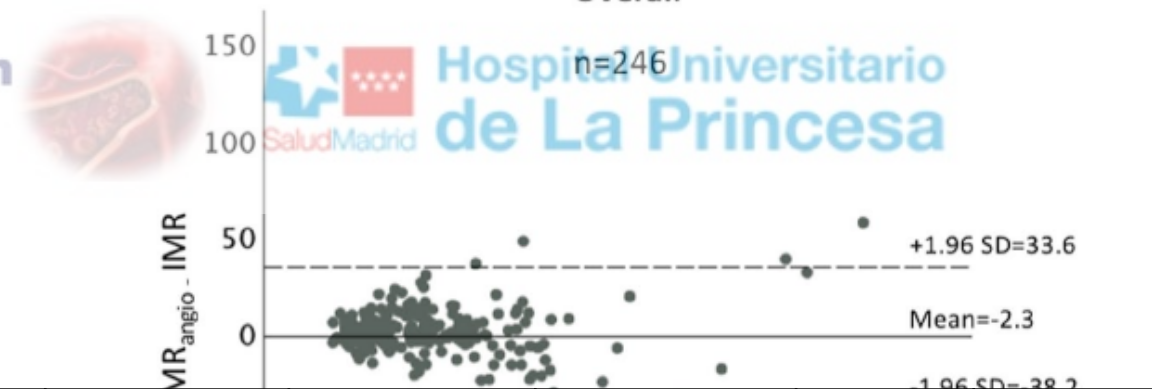
$$\text{IMR} = \text{Pd} \times \text{tTmn}$$

IMR_{angio}

$$\text{IMR}_{\text{angio}} = \text{Pa} \times \text{QFR} \times (\text{N frames}/\text{fps})$$



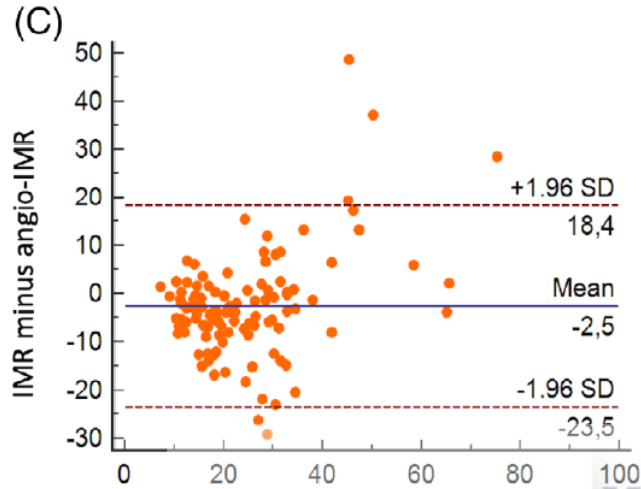
Hyperaemia Induction



	Accuracy (%)	Sensitivity (%)	Specificity (%)	NPV (%)	PPV (%)
STE-ACS (40UI)	88.6	84.3	92.1	87.9	89.6
NSTE-ACV (25UI)	73.3	80.9	69.2	87.1	58.6
CCS (25 UI)	78.4	72.7	82.8	80.0	76.2

Mean of IMR_{angio} and IMR





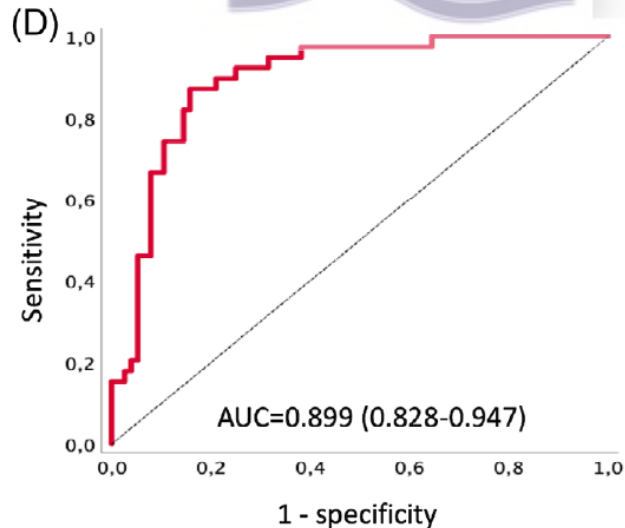
IMR $IMR = Pd \times tTmn$

IMR_{angio} $IMR = (Pa - [0.1 \times Pa]) \times QFR \times (\text{vessel Length} / \text{flow vel})$

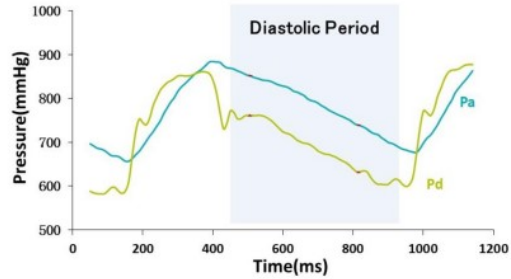
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	Accuracy (%)	Sensitivity (%)	Specificity (%)	NPV (%)	PPV (%)
Cutt-off Point (23UI)	85.0	87.5	85.3	92.8	76.1



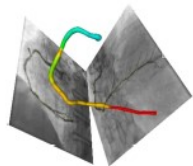
IMR $IMR = Pd \times tTmn$

IMR_{angio} $IMR = (Pa - \Delta P) \times (L/K \times V_{el\text{diastole}})$

At diastole, flow velocity is proportional to that in hyperemia because microvascular resistance is proportional to that in hyperemia.

MMM

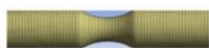
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Angiograms from two projections

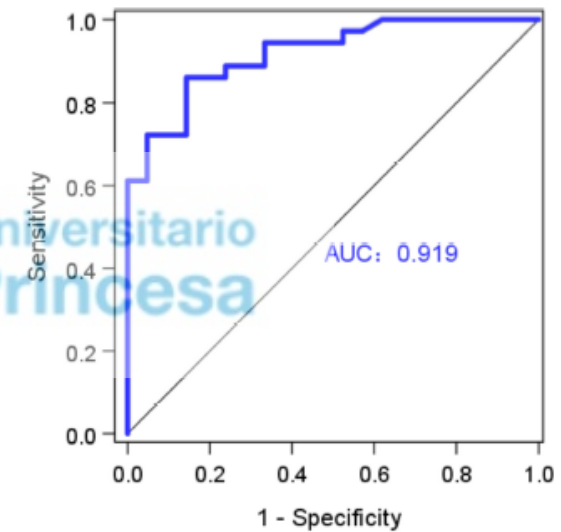
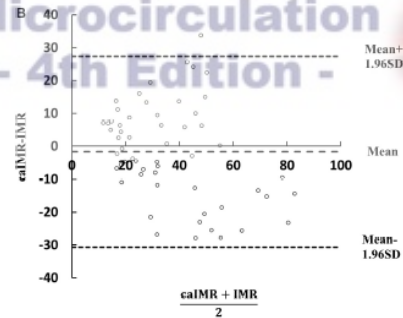


Aortic pressure wave



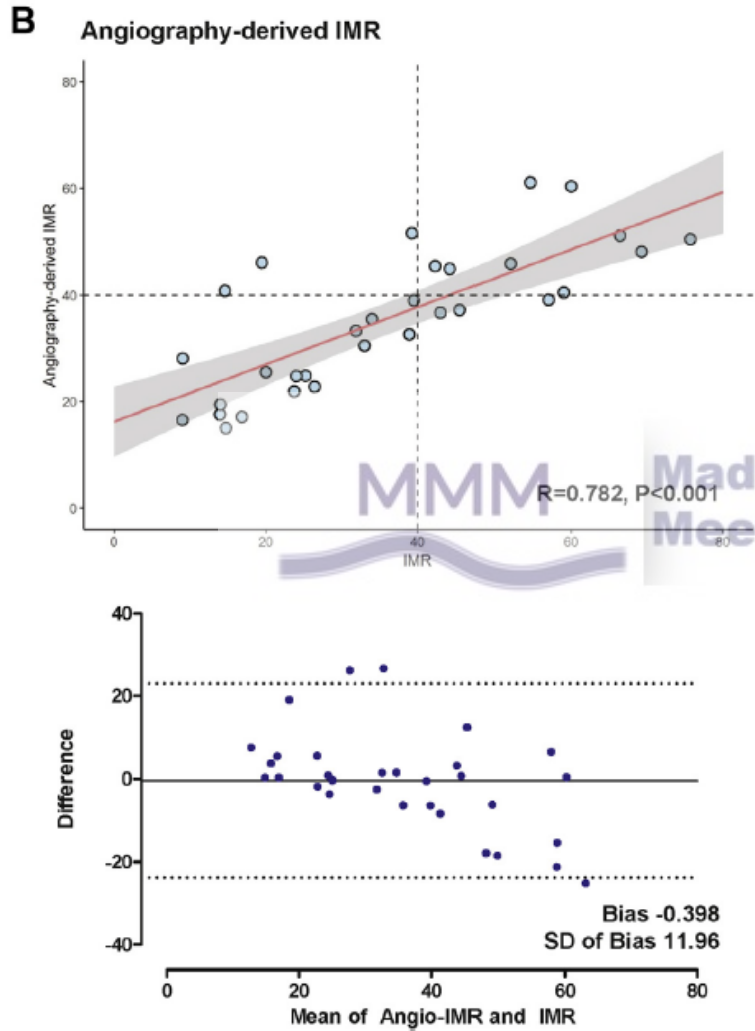
CFD

Based on the aortic pressure waveform, coronary angiography, and CFD simulation, a new physiological parameter is defined as: coronary angiography-derived index of microvascular resistance ($caIMR = (P_d)_{hyp} \frac{L}{K \cdot V_{diastole}}$)

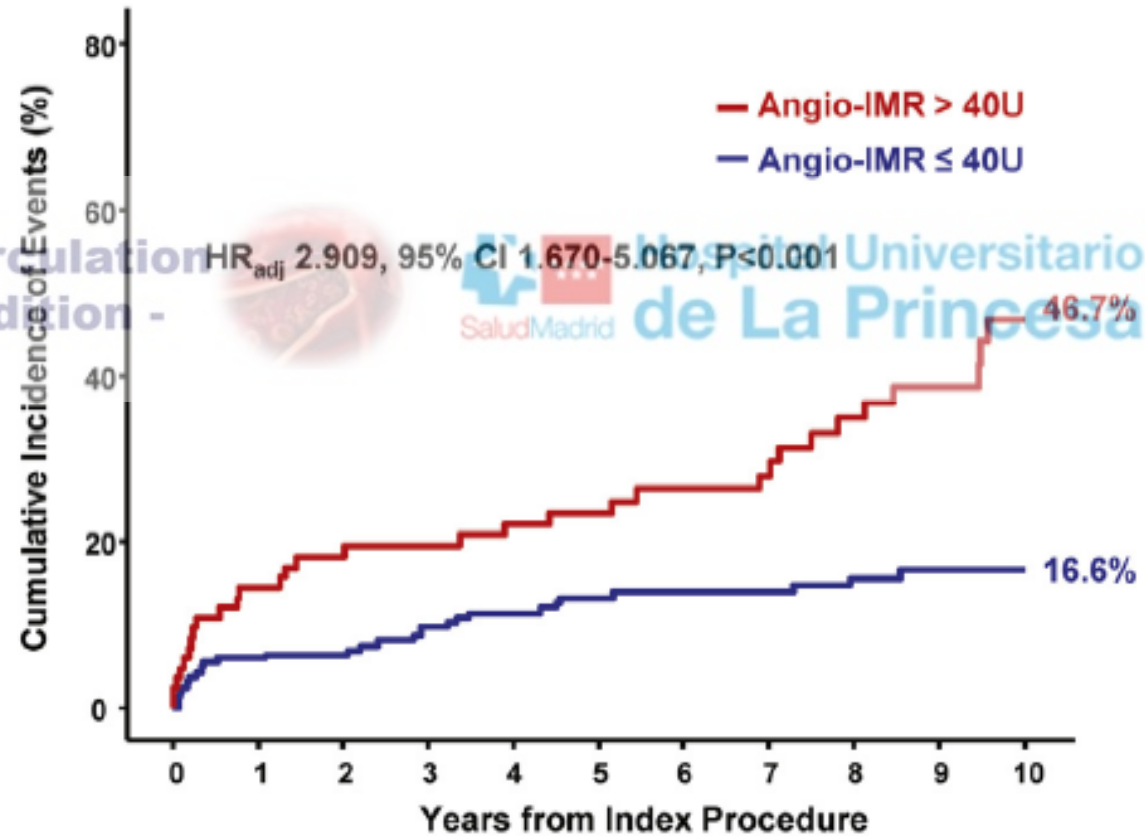


	Accuracy (%)	Sensitivity (%)	Specificity (%)	NPV (%)	PPV (%)
Cutt-off Point (25UI)	84.2	86.1	81.0	77.3	88.6





A Angio-IMR > 40U vs. \leq 40U



Number at risk	
84	225
70	203
66	184
63	163
59	144
56	131
47	116
42	107
36	94
26	67
19	41

(%)	PPV (%)
4.2	80.6

Cutt-off



Article
In Vivo Validation of a Novel Computational Approach to Assess Microcirculatory Resistance Based on a Single Angiographic View

Yongzhen Fan ^{1,2}, Simone Fezzi ^{3,4}, Pengcheng Sun ⁵, Nan Ding ⁵, Xiaohui Li ⁵, Xiaorong Hu ^{1,2}, Shuang Wang ⁶, William Wijns ³, Zhibing Lu ^{1,2,*} and Shengxian Tu ^{7,*}



IMR = Pd x tTmn

IMR_{angio} = (Pa x QFR) / Velocity, computed from angio

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Table 3. The diagnostic performance of AMR in predicting IMR ≥ 25.

Best Cutoff Value for AMR	AMR > 2.5
Accuracy, % (95% CI)	87.2 (83.0–91.3)
Sensitivity, % (95% CI)	93.5 (87.0–97.3)
Specificity, % (95% CI)	82.7 (75.6–88.4)
PPV, % (95% CI)	79.4 (71.2–86.1)
NPV, % (95% CI)	94.7 (89.3–97.8)
+LR, (95% CI)	5.39 (3.80–7.70)
-LR, (95% CI)	0.08 (0.04–0.20)

LR, likelihood ratio; NPV, negative predictive value; PPV, positive predictive value.

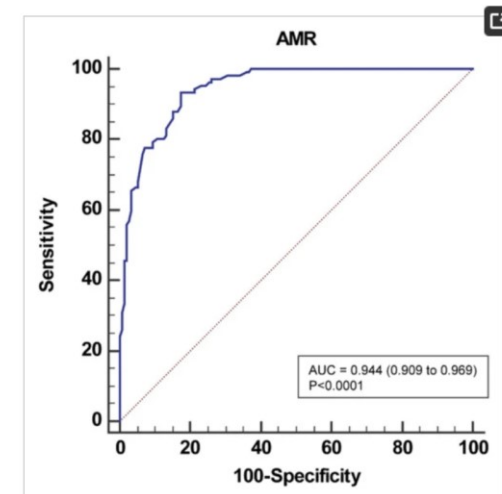
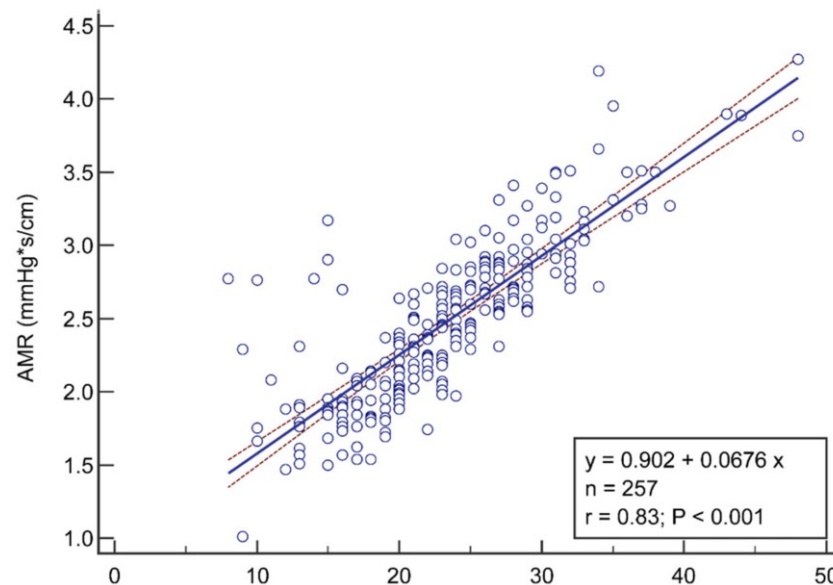
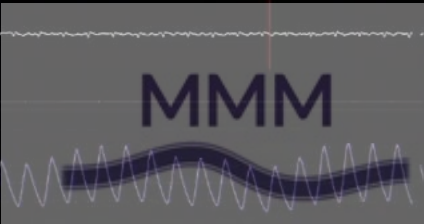
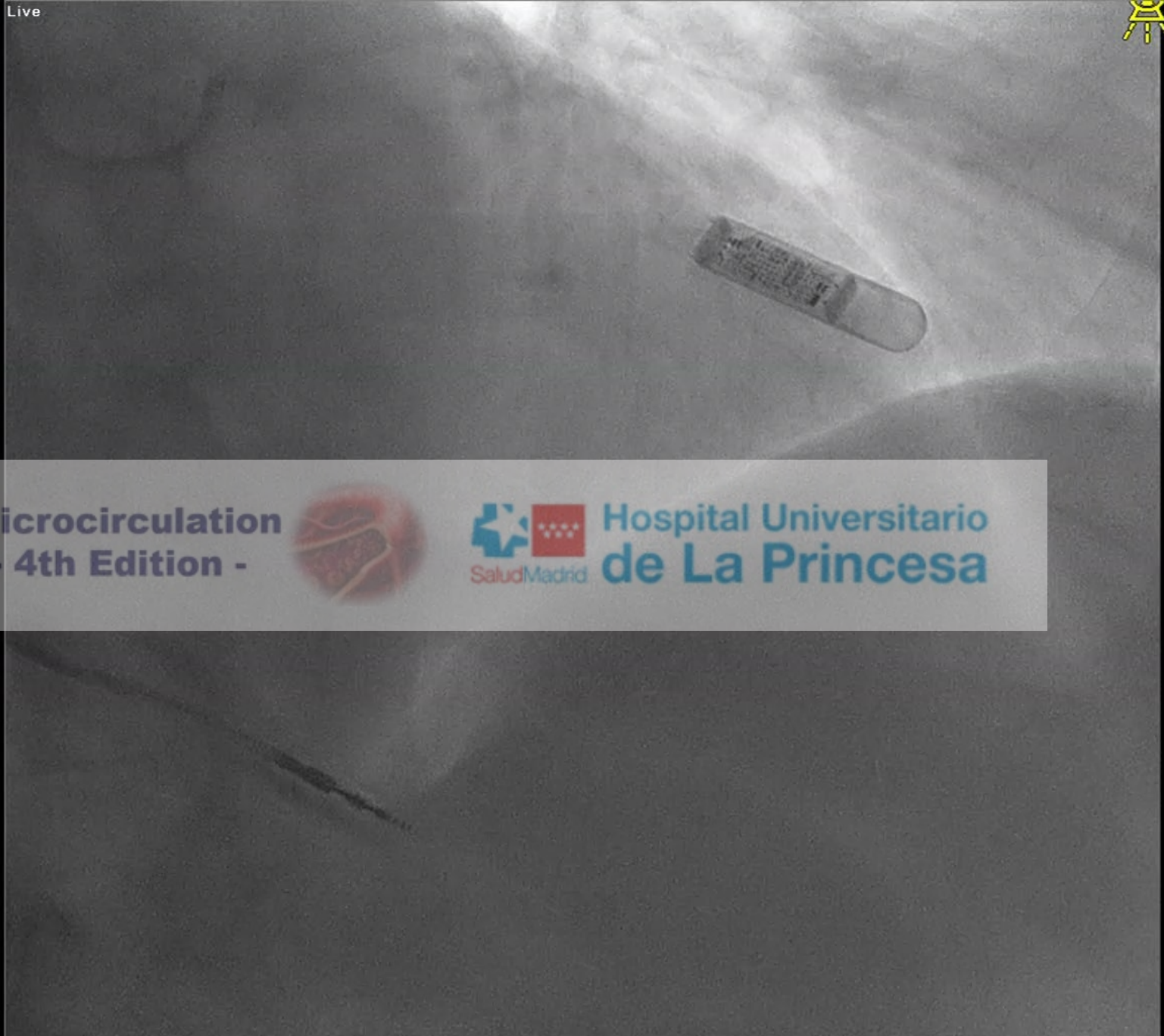


Figure 2. Receiver-operating characteristic curve analysis of AMR for identifying IMR ≥ 25U. AMR, angio-derived microcirculatory resistance; IMR, index of microvascular resistance.

Camara Brazo



Live

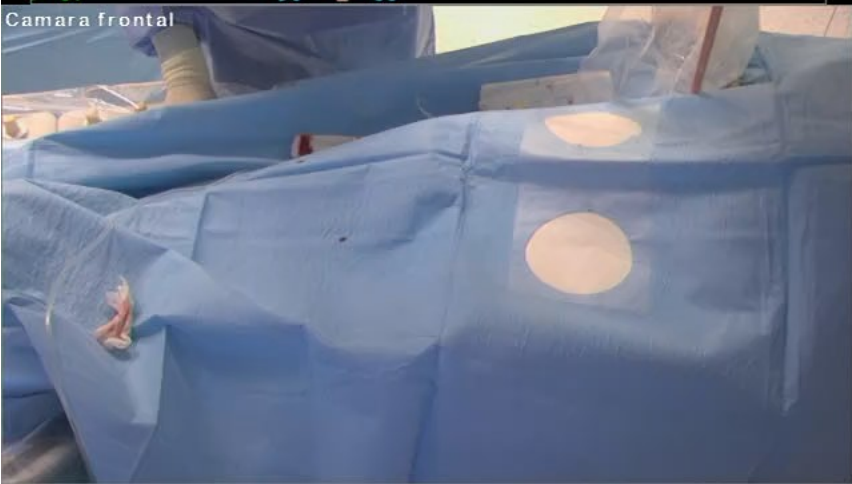


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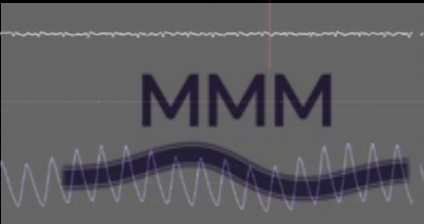
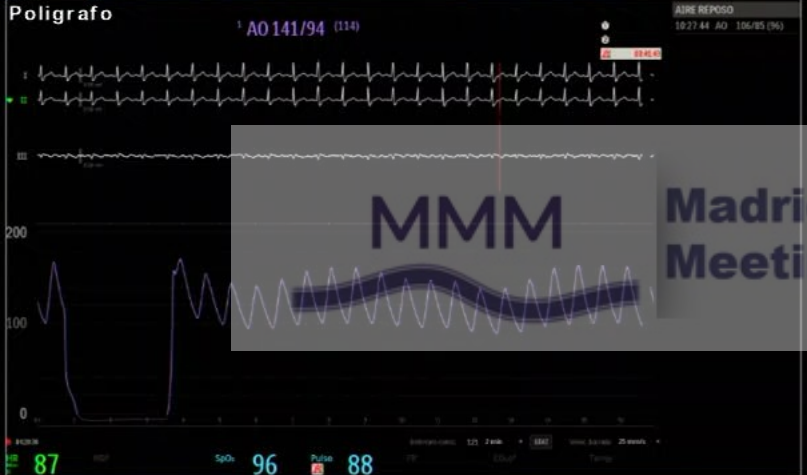
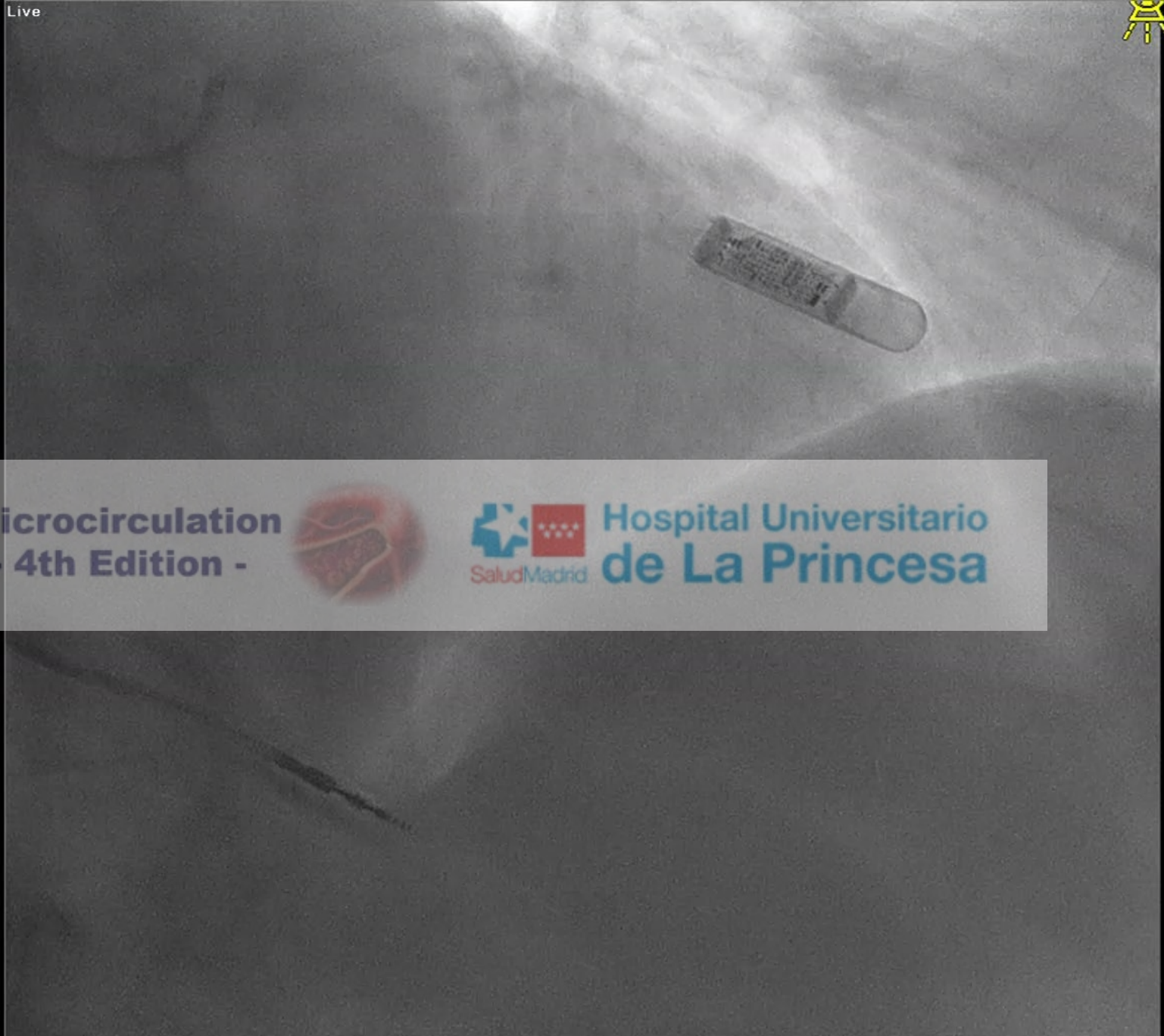
Camara frontal



Camara Brazo



Live

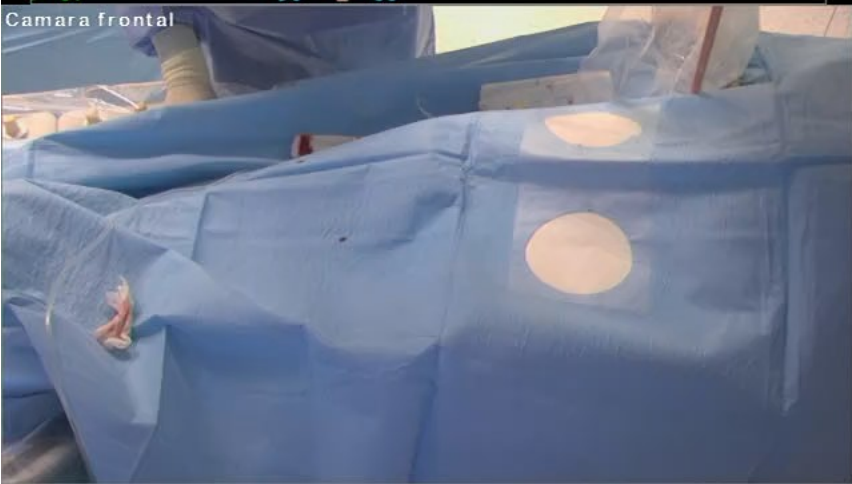


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Camara frontal



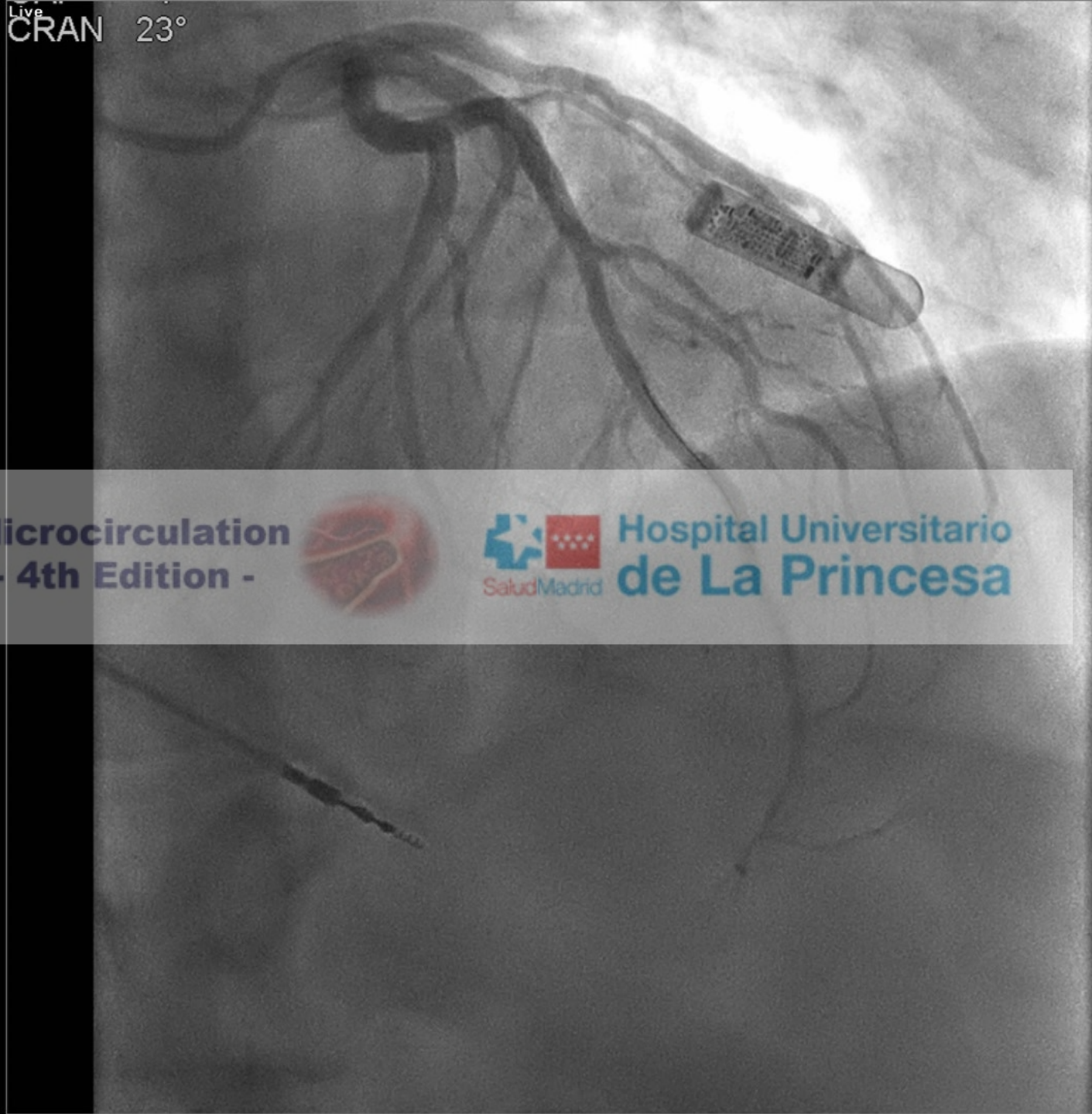
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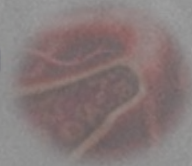
Camara frontal



Live CRAN 23°



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Series No.3
2023-11-03 13:37:07
Frame rate: 15.0 f/s

0.98
Vessel μ FR

7.5 mm
2.0/2.0 mm
 $\Delta\mu$ FR 0.01

0.99
Residual μ FR

Branch Map

[Murray] Diameter



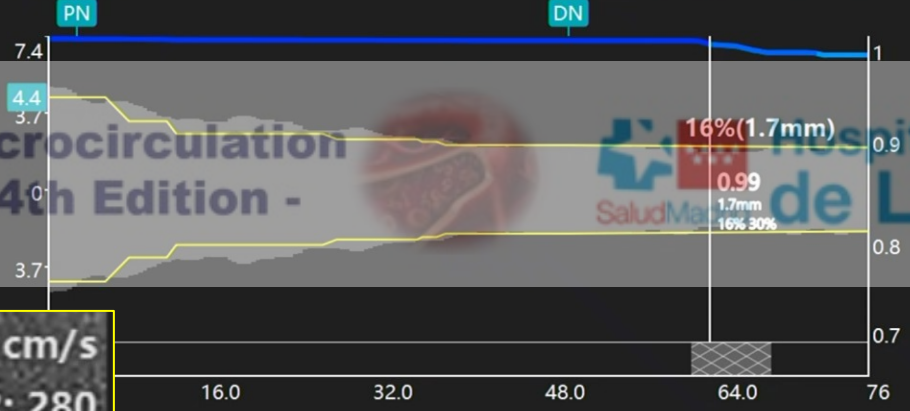
Lock Pathline

+ Add Branch

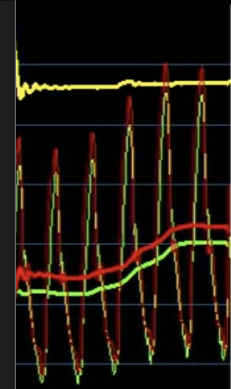
Delete

LM+LAD

Pullback Curve 1



Flow: 14.3 cm/s
MR: 280



FFR	Pd	Pa
0.95	113	119

Pd/Pa	Pd	Pa
0.95	111	117

CFR	CFR _{Norm}
1.3	1.4

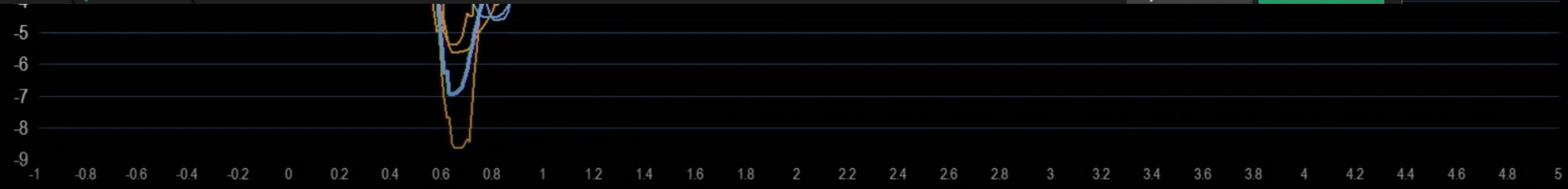
IMR	IMR _{Corr}
30	31

RRR
1.3

51/82
WL: 128 WW: 256
LAO: 4.0 CRA: 30.5
Cal. fac.: 0.22 mm/px (Isocenter)

Flow μ FR-2D

μ FR-3D DONE



Reanudar

En vivo

Conclusions

1/ Good performance have been shown of Angio-IMR in assessing the microcirculation status as compared to IMR in both acute and chronic coronary syndromes

2/ Different approaches to calculate Angio-IMR have been proposed, newer generations calculates microvascular resistances automatically

3/ Further prospective studies are needed to investigate its prognostic value and if this information could change clinical decisions