CUORE
E NON SOLO
INTERVENTIONAL CARDIOLOGY
14/15.04.23
GENOVA

Valutazione dello shear stress endoteliale: solo per la ricerca?

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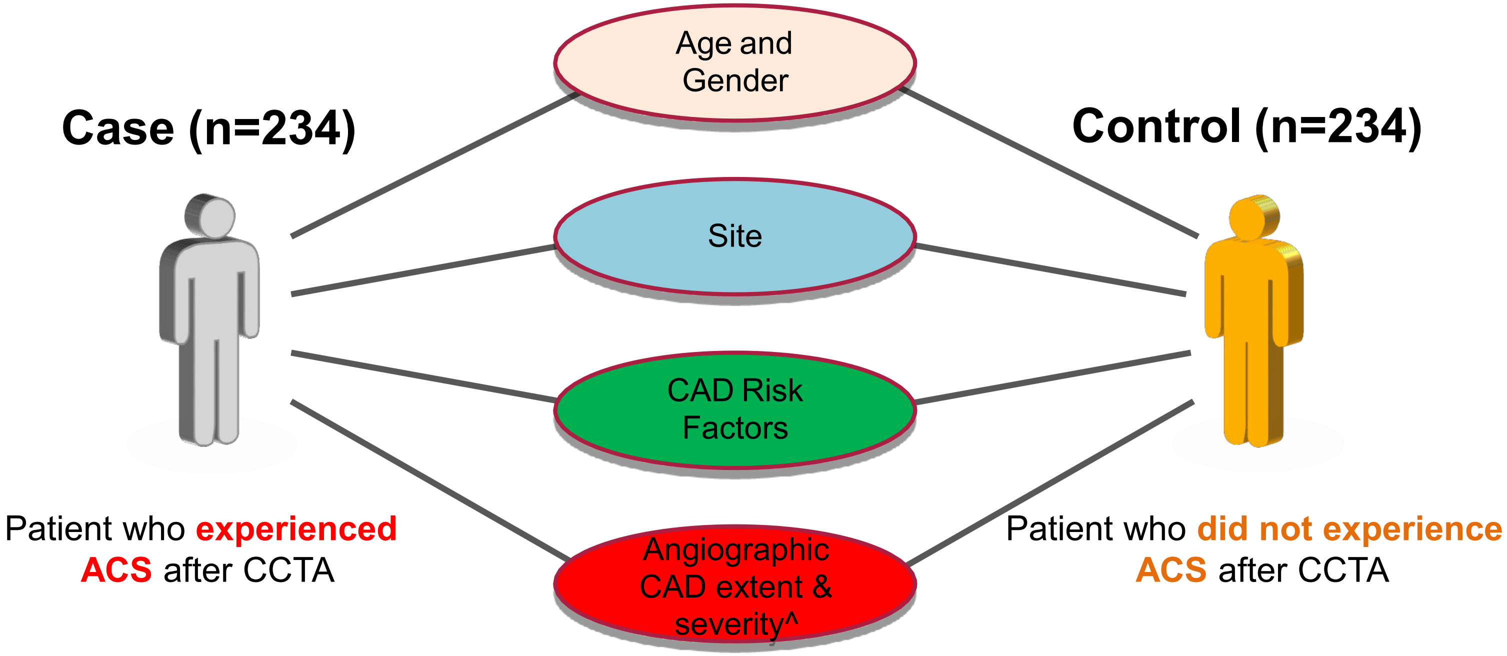
DISCLOSURES

1) Abbott
2) Chiesi
3) Edwards
4) Medtronic

CLINICAL GAP

CLINICAL GAP: IDENTIFICATION OF «FUTURE CULPRIT»

ICONIC STUDY:
25.251 patients performed CT at basal and after 3.4 years

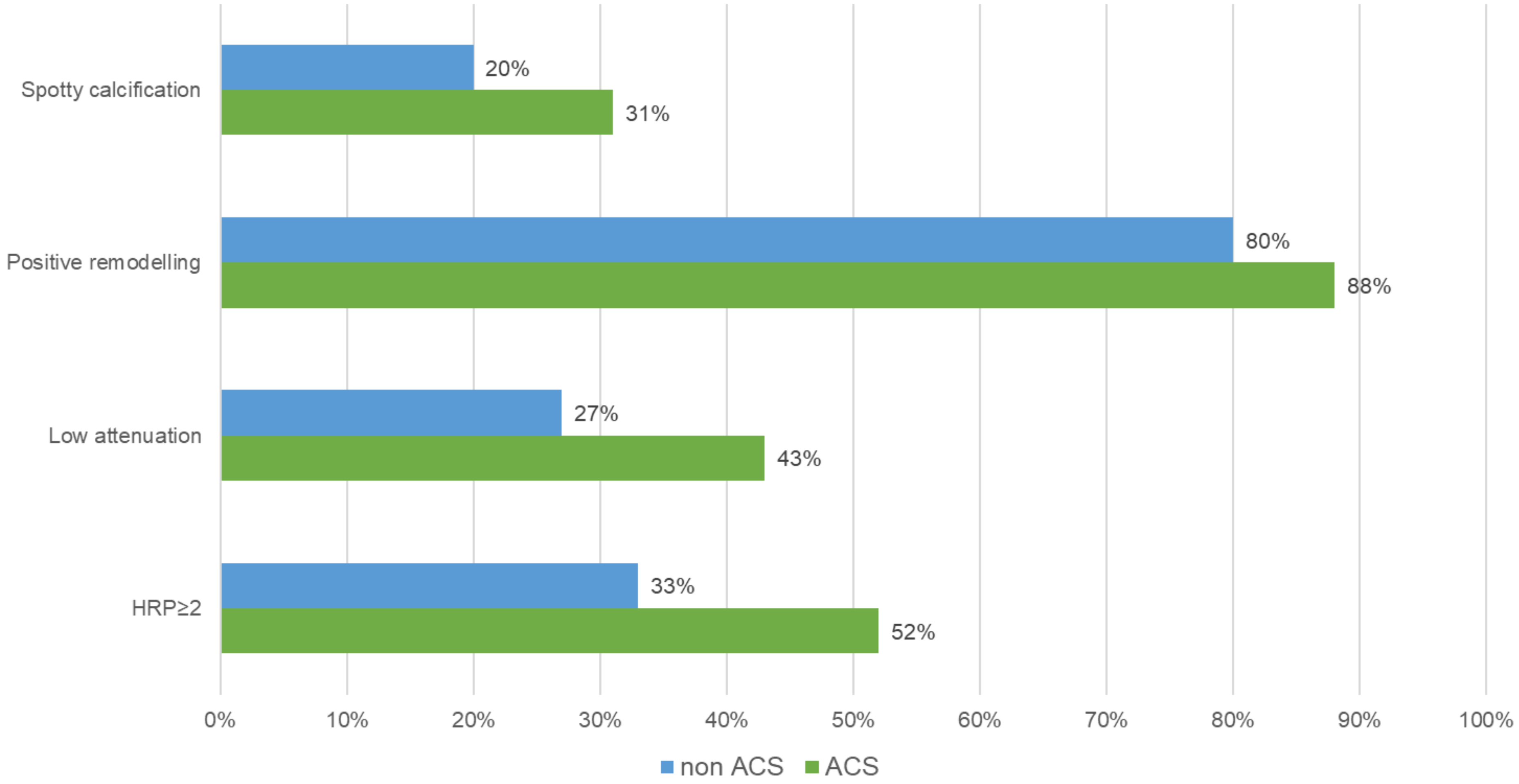


When angiographic CAD extent and severity is the same, do atherosclerotic plaque characteristics matter?

Chang, Jacc 18

Coronary Atherosclerotic Precursors of Acute Coronary Syndromes

CLINICAL GAP: IDENTIFICATION OF «FUTURE CULPRIT»



Chang, Jacc 18

Coronary Atherosclerotic Precursors of Acute Coronary Syndromes

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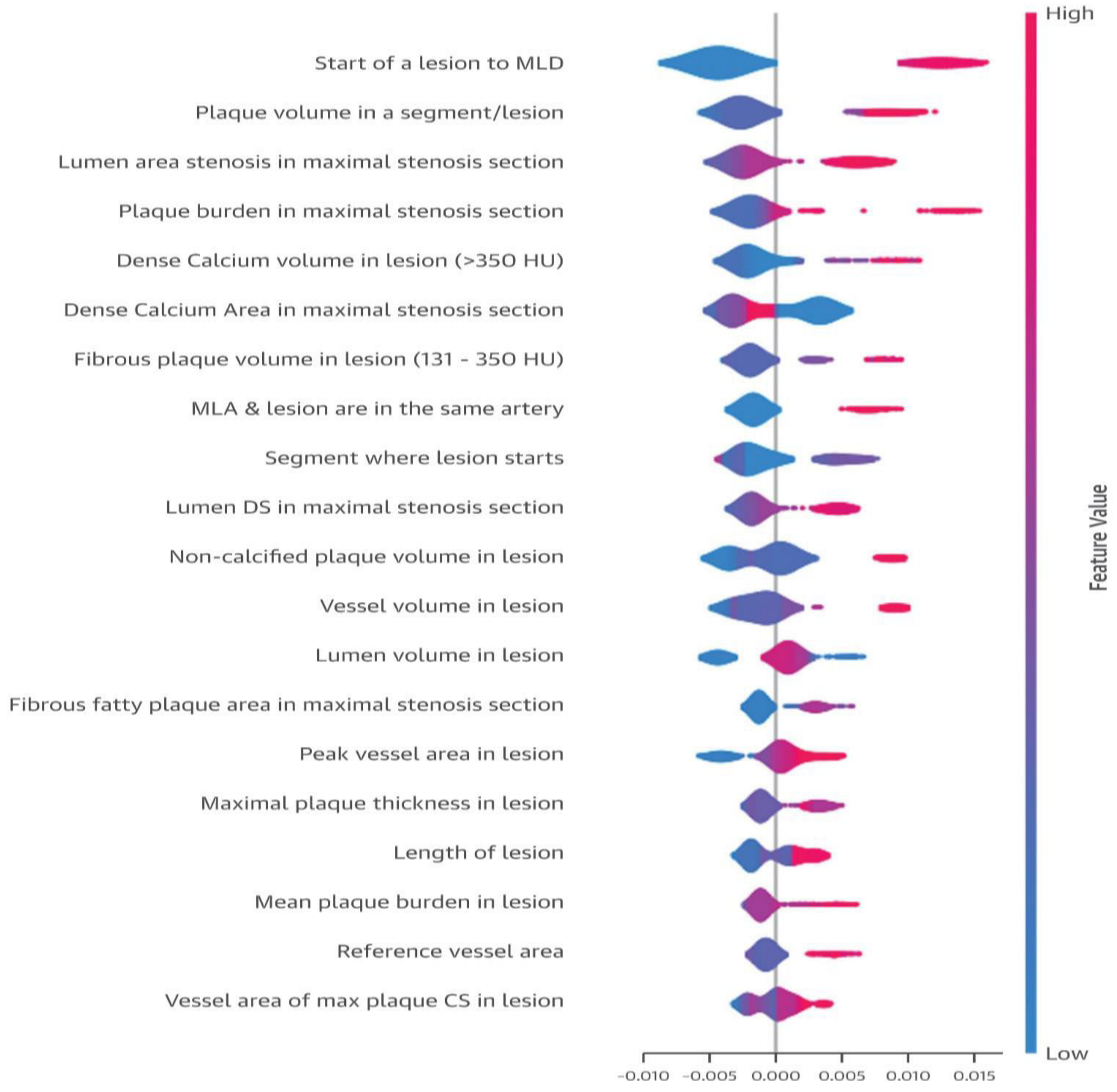
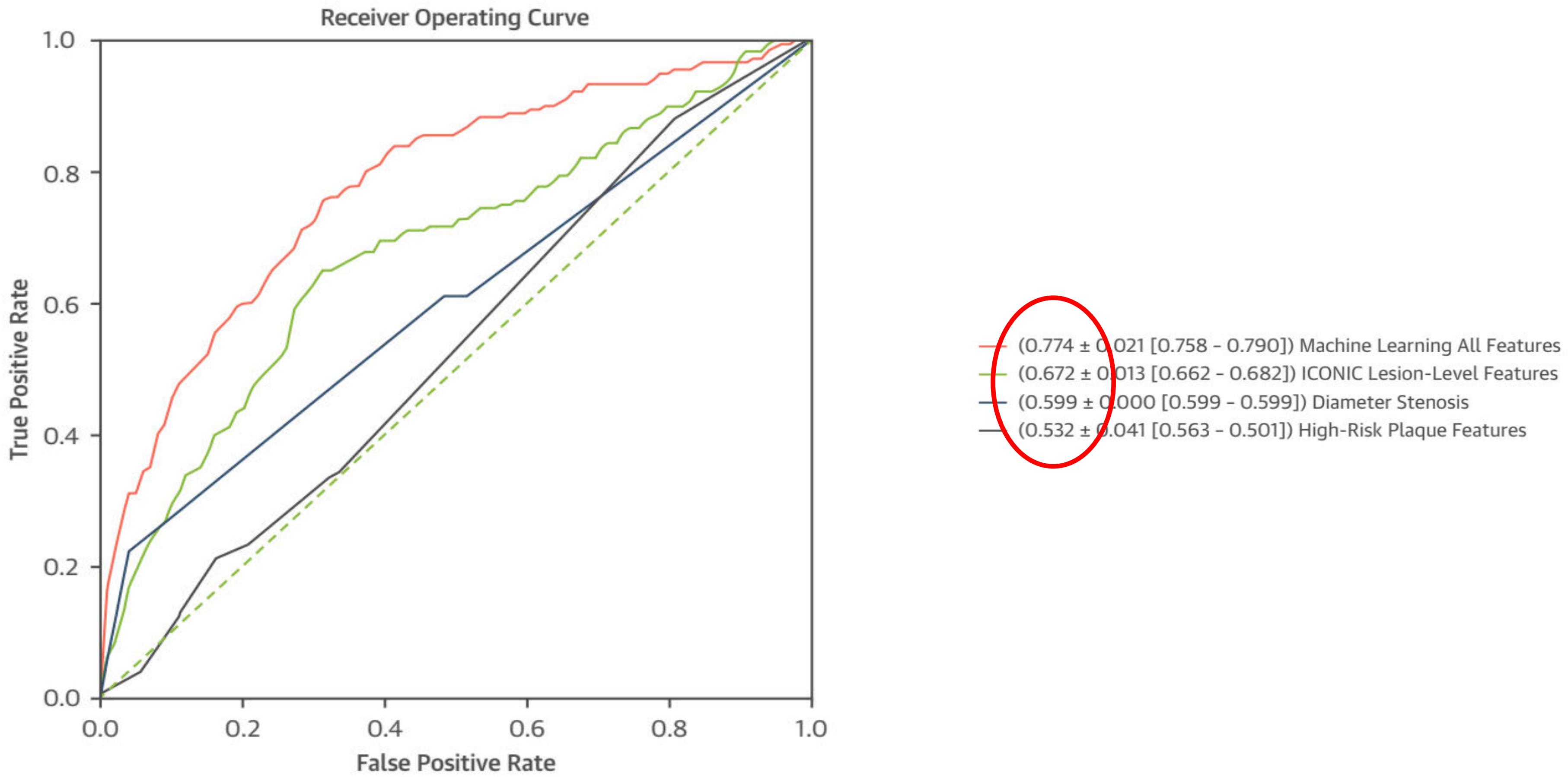


A Boosted Ensemble Algorithm for Determination of Plaque Stability in High-Risk Patients on Coronary CTA

Al Aref, Jacc 20

CLINICAL GAP: IDENTIFICATION OF «FUTURE CULPRIT»



A Boosted Ensemble Algorithm for Determination of Plaque Stability in High-Risk Patients on Coronary CTA

Al Aref, Jacc 20

CLINICAL GAP: IDENTIFICATION OF «FUTURE CULPRIT»

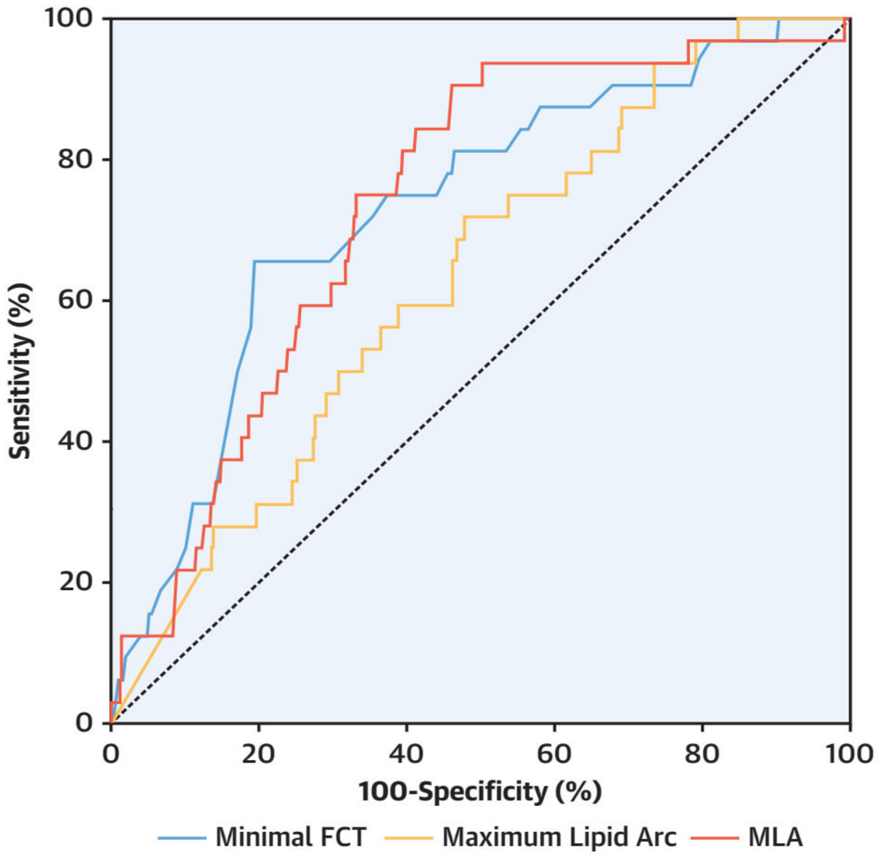
OCT of 883 pts in non culprit arteries followed for 4 years

Patient-level models[a] with each high-risk characteristic introduced separately		
Model 1: TCFA	3.05 (1.67-5.57)	<0.001
Model 2: MLA <3.5 mm^2	3.71 (1.22-11.34)	0.021
Model 3: TCFA+MLA <3.5 mm^2	5.75 (3.12-10.61)	<0.001
Lesion-level models[b] with each high-risk characteristic introduced separately		
Model 1: TCFA	8.15 (3.67-18.07)	<0.001
Model 2: MLA <3.5 mm^2	4.33 (1.81-10.38)	0.001
Model 3: TCFA+MLA <3.5 mm^2	15.50 (6.89-34.89)	<0.001
Lesion-level models with 2 high-risk characteristics introduced simultaneously		
TCFA	7.64 (3.42-17.09)	<0.001
MLA <3.5 mm^2	4.11 (1.72-9.82)	0.002

Jiang, Jacc 2023

Identification of High-Risk Coronary Lesions by 3-Vessel Optical Coherence Tomography

CLINICAL GAP: IDENTIFICATION OF «FUTURE CULPRIT»



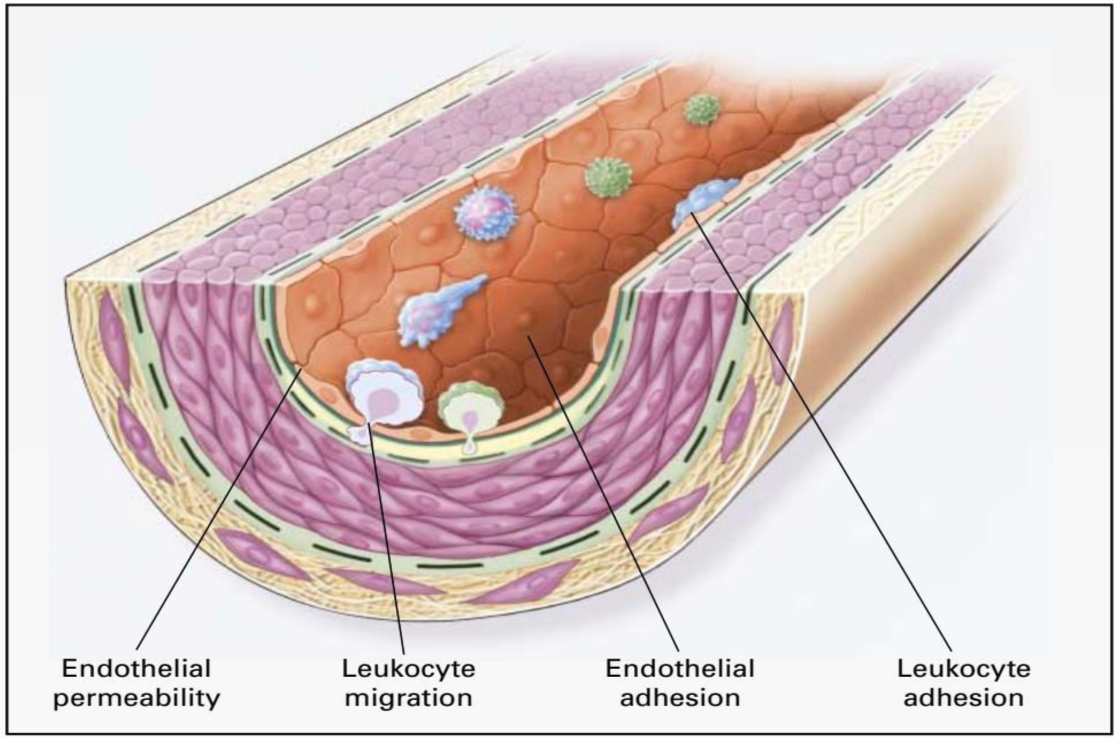
Variables	Optimal Cut-Off	AUC (95% CI)	Youden's Index	Sensitivity	Specificity	*P* Value
Minimal FCT, μm	66.7	0.73 (0.71-0.75)	0.46	65.6%	80.6%	<0.001
Maximum Lipid Arc, °	225.7	0.63 (0.61-0.65)	0.24	71.9%	52.2%	0.003
MLA, mm^2	3.54	0.74 (0.72-0.75)	0.44	85.3%	58.8%	<0.001

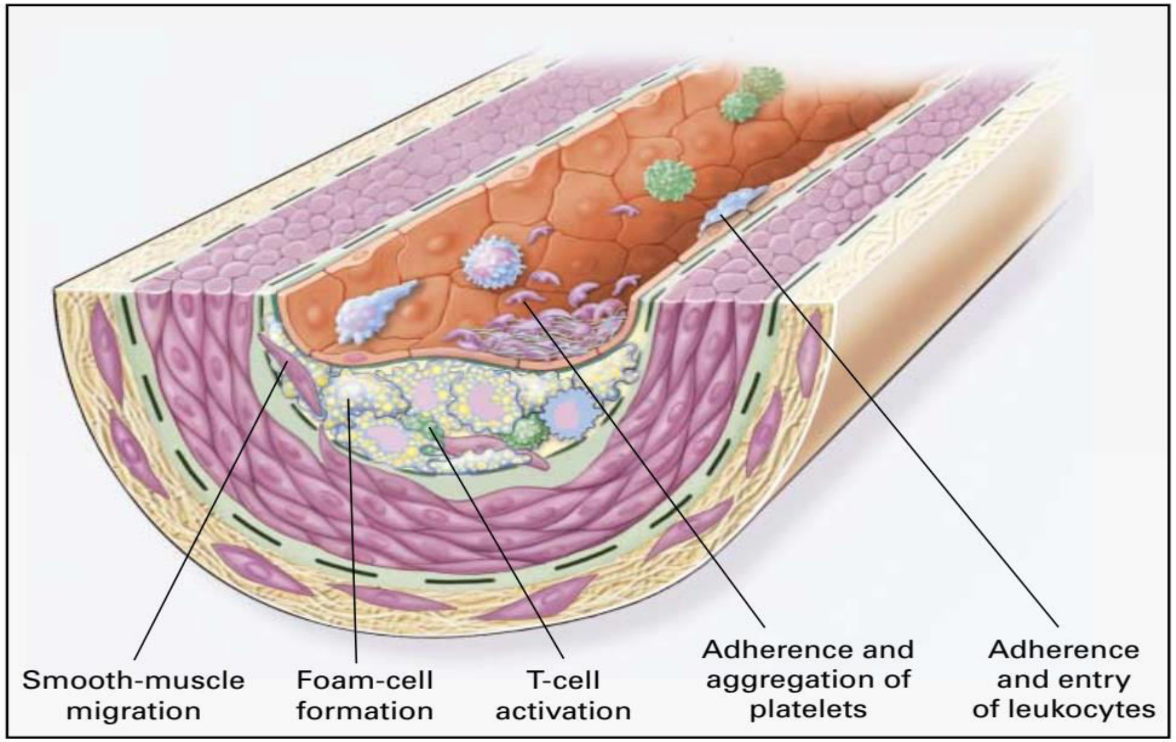
Jiang, Jacc 2023

Identification of High-Risk Coronary Lesions by 3-Vessel Optical Coherence Tomography

WSS DEFINITION AND MECHANISM

THE ROLE OF INFLAMMATION

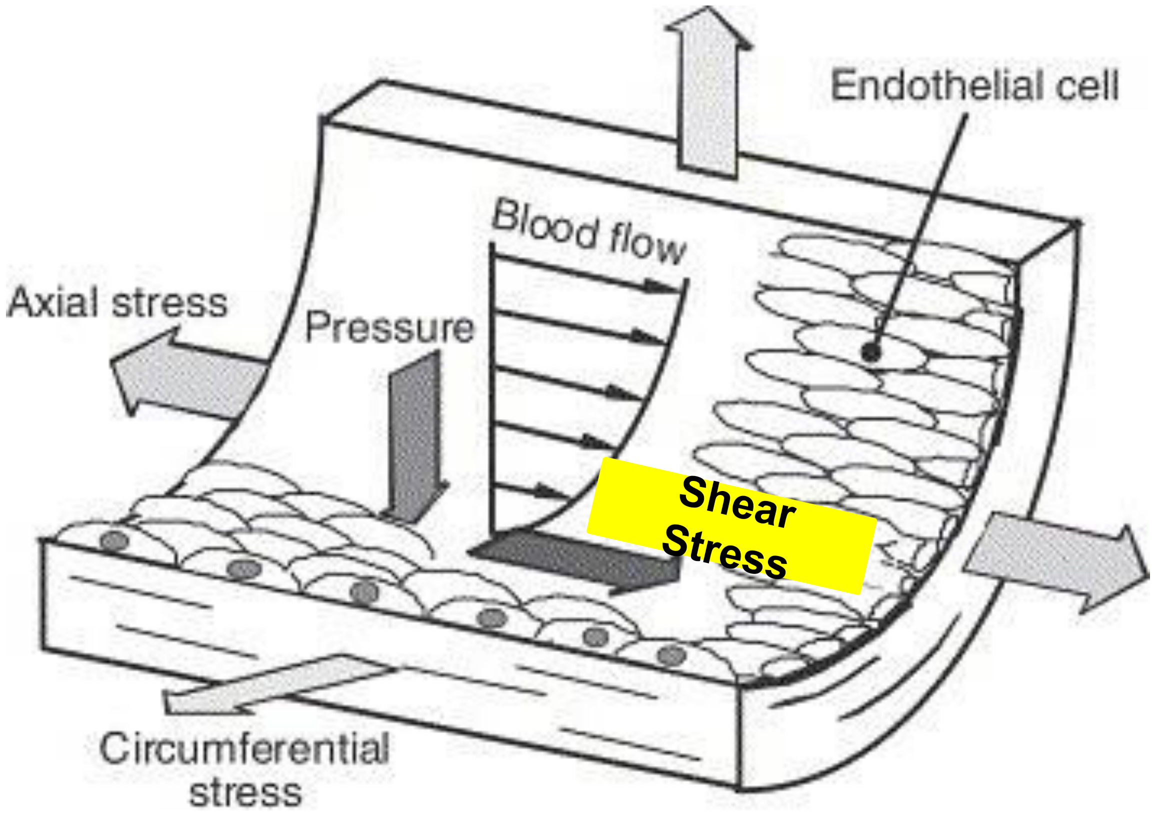




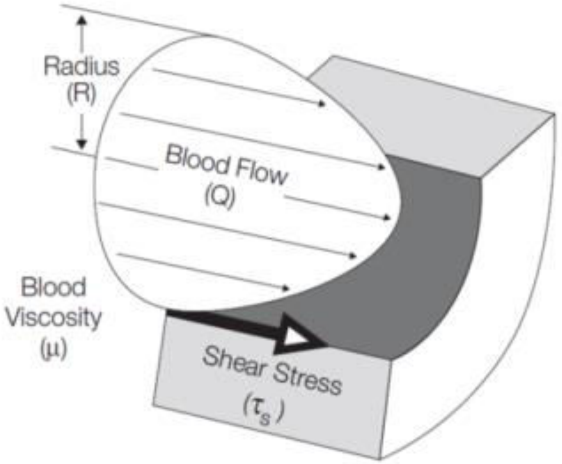
Ross, Nejm 1999

ATHEROSCLEROSIS — AN INFLAMMATORY DISEASE

THE ROLE OF BIOMECHANICAL FORCES



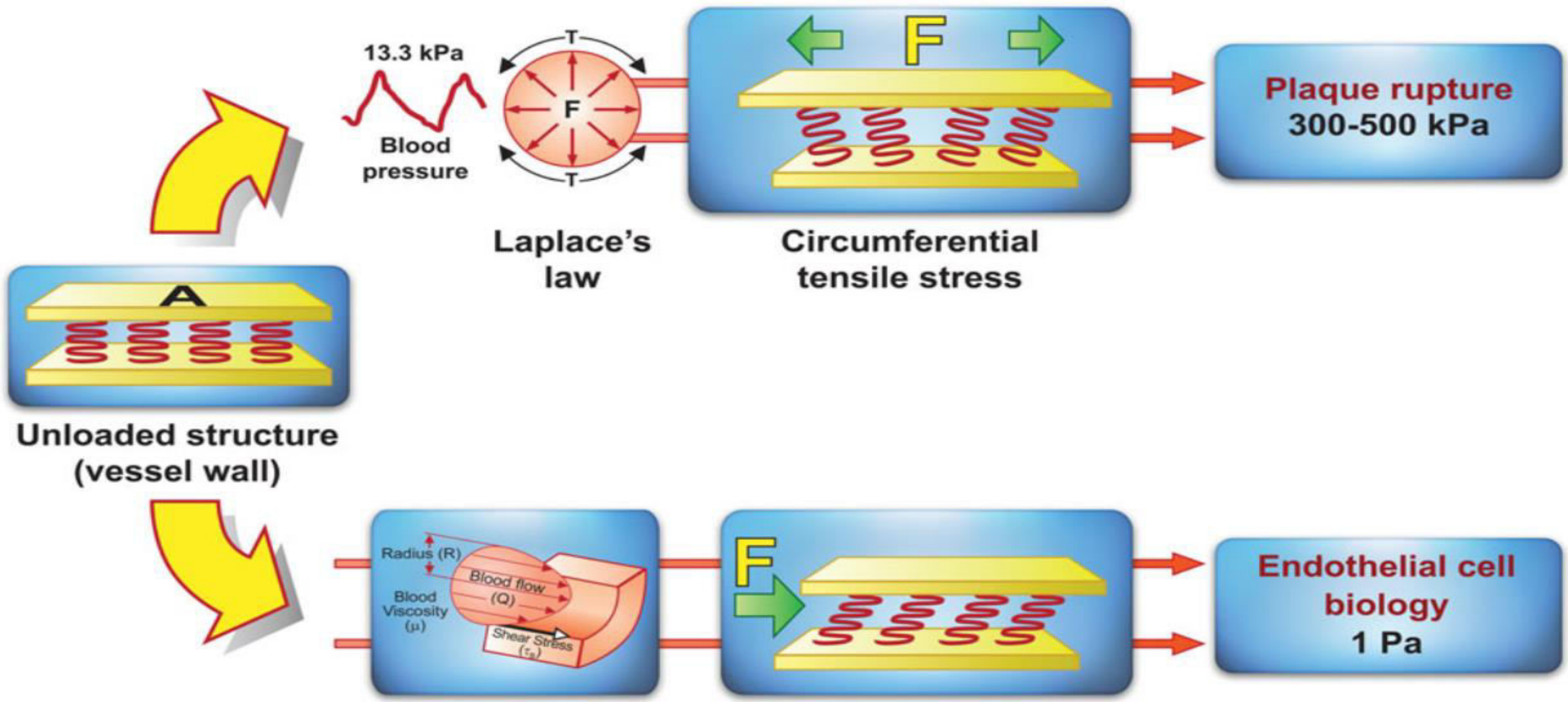
Wss= tangential force/area (dynes/cm2)



Gijesn, EHJ 2019

Expert recommendations on the assessment of wall shear stress in human coronary arteries: existing methodologies, technical considerations, and clinical applications

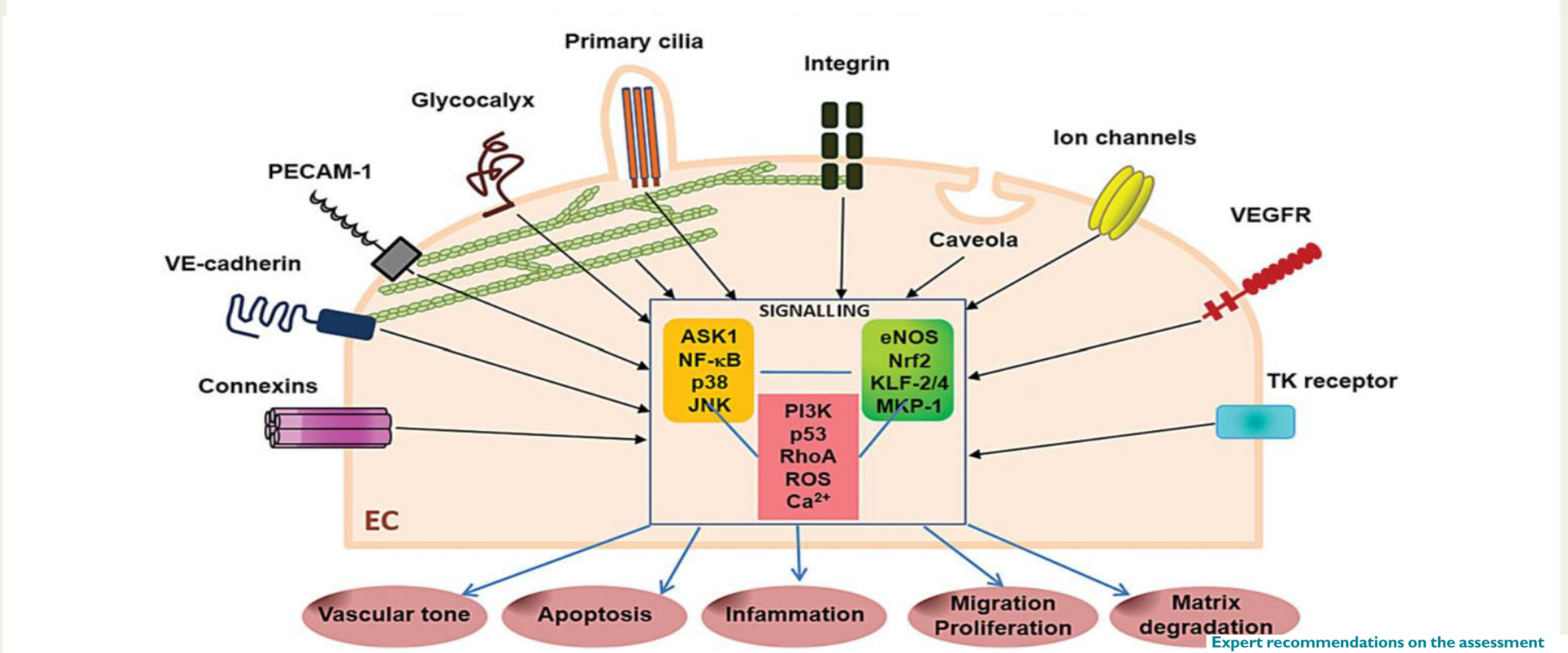
THE ROLE OF BIOMECHANICAL FORCES



Gijesn, EHJ 2019

existing methodologies, technical
considerations, and clinical applications

IMPACT OF WSS ON ENDOTHELIUM



Expert recommendations on the assessment of wall shear stress in human coronary arteries: existing methodologies, technical considerations, and clinical applications

Gijesn, EHJ 2019

IMPACT OF WSS ON ENDOTHELIUM

		Effects in:		
Label	**Range (Pa)**[18–22]	**Early atherosclerosis**[4]	**Advanced atherosclerosis**[4]	**Stented segments**[23,24]
Oscillatory	0 ± 0.5	Athero-prone	Athero-prone	Neoathero-prone
Low	0–1			
Normal/high	1–7	Athero-protective	No consensus[a]	Neoathero-protective
Elevated	>7	NA	Erosion	NA

Gijesn, EHJ 2019

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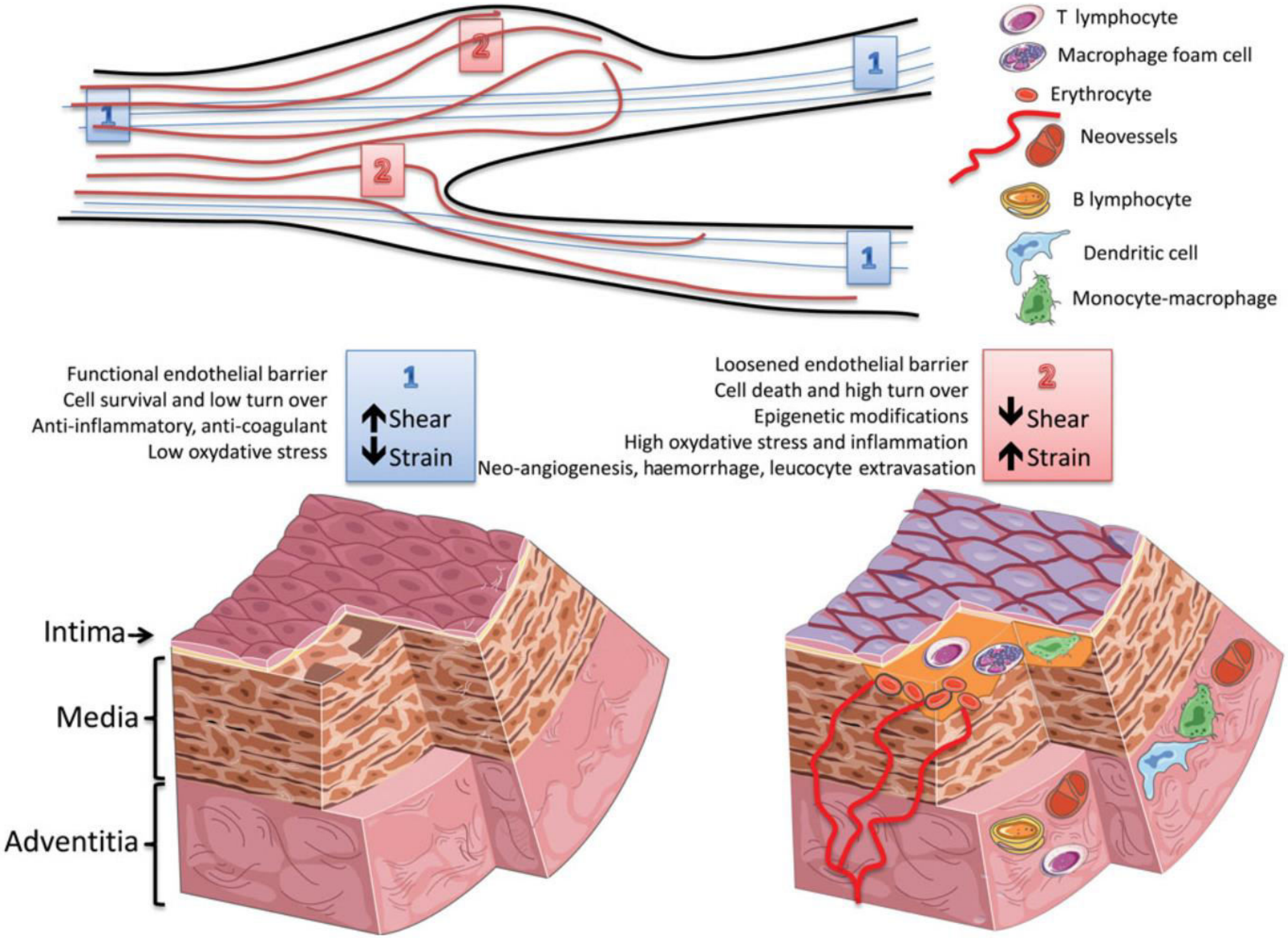
IMPACT OF WSS ON ENDOTHELIUM



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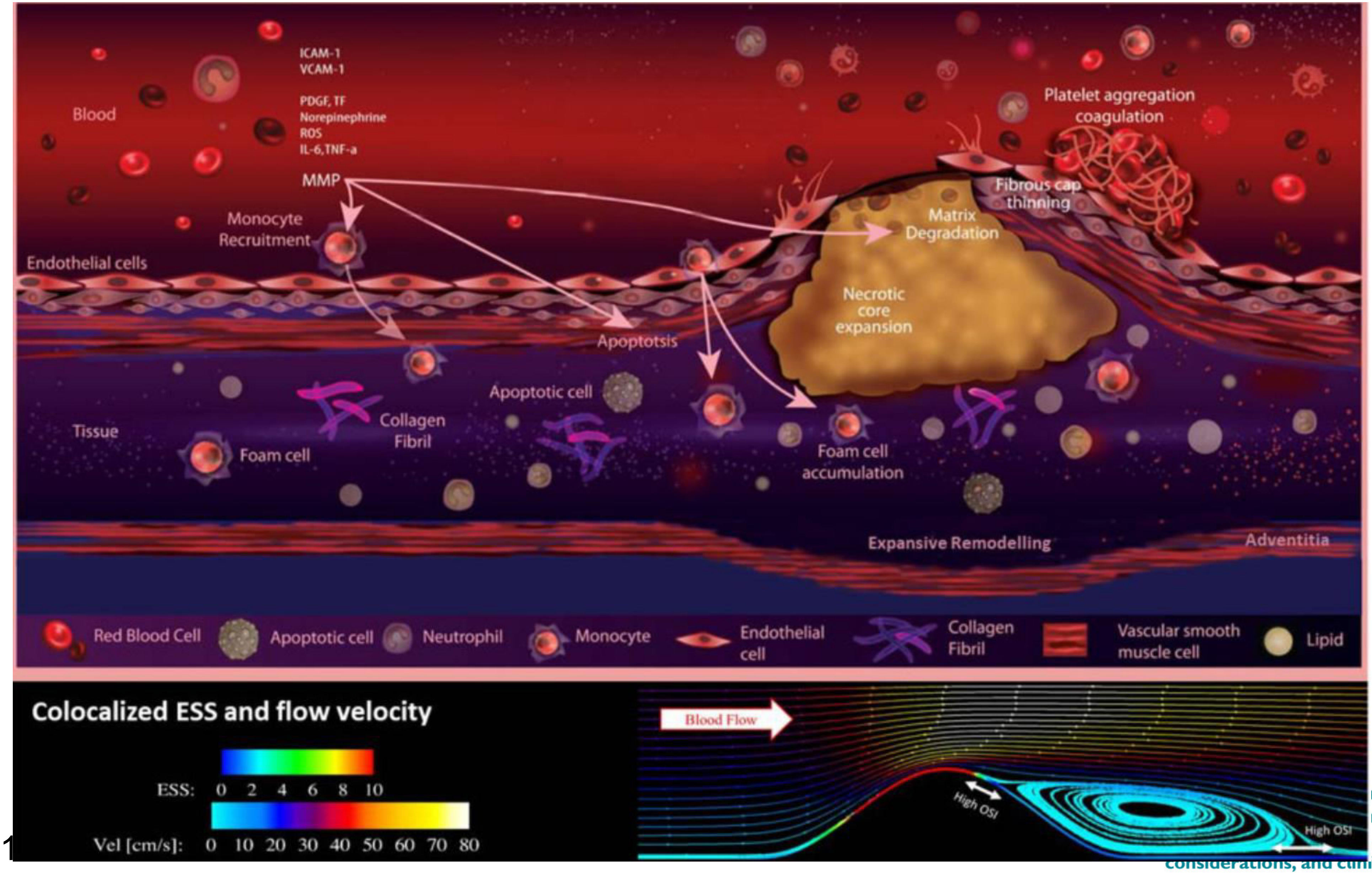
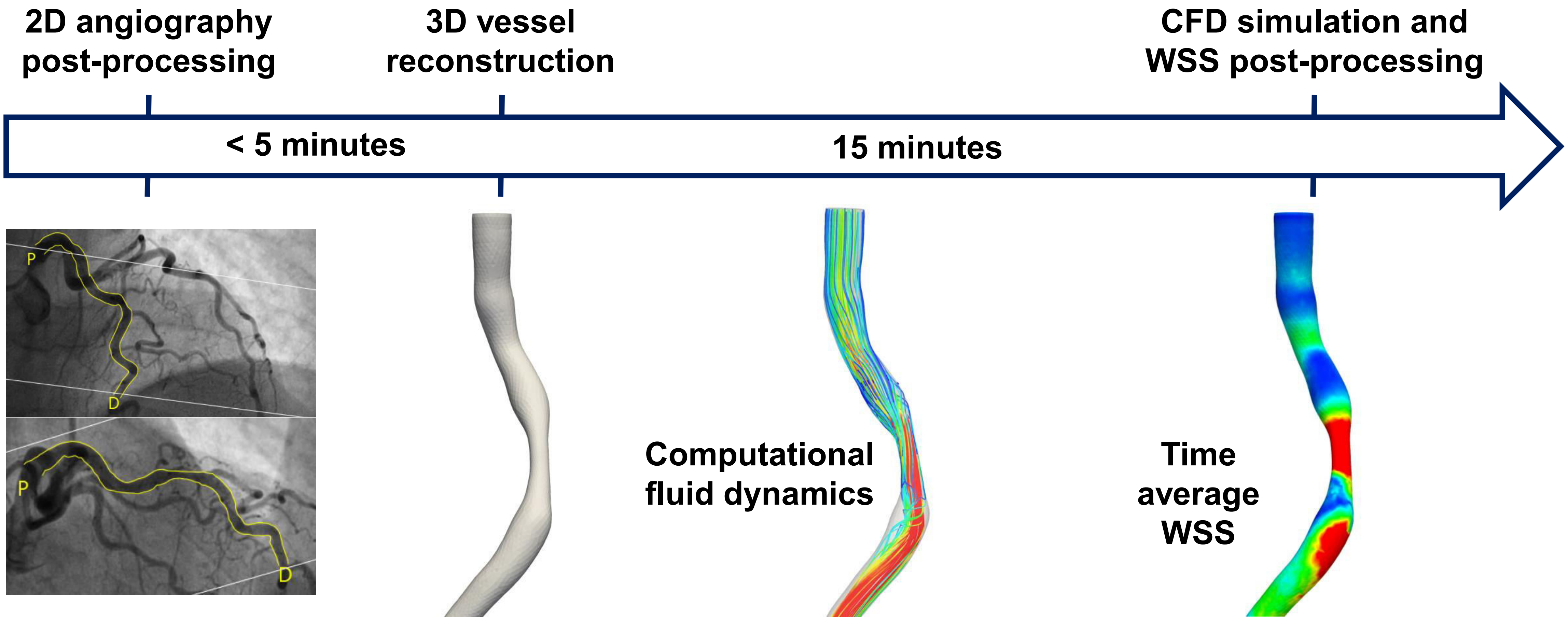


Gijesn, EHJ 201

ns on the assessment
man coronary arteries:
technical
considerations, and clinical applications

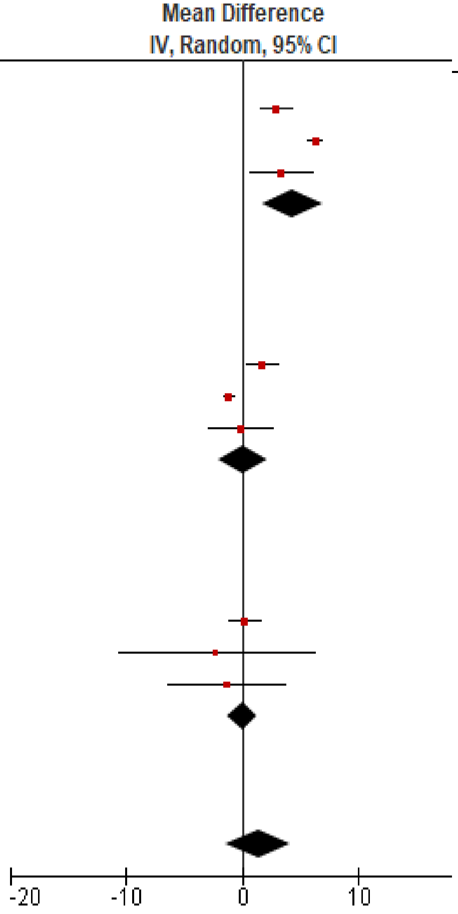
HOW TO OBTAIN WSS



PLAQUE PROGRESSION AND ROLE OF WSS

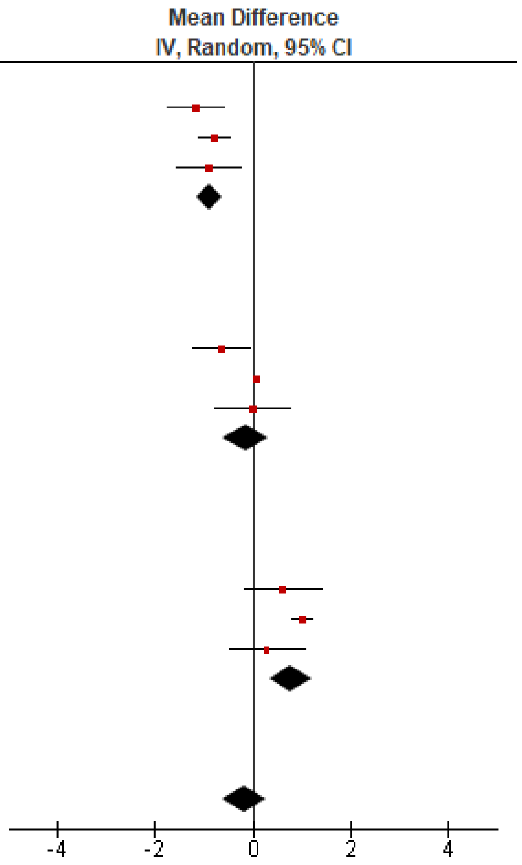
PLAQUE PROGRESSION AND ROLE OF WSS

Study or Subgroup	Mean Difference	SE	Weight	Mean Difference IV, Random, 95% CI
1.2.1 Low SS				
Hartman, 21	2.9	0.7	12.3%	2.90 [1.53, 4.27]
Liu, 17	6.3	0.3	12.6%	6.30 [5.71, 6.89]
Samady, 11	3.4	1.4	11.4%	3.40 [0.66, 6.14]
Subtotal (95% CI)			**36.3%**	**4.32 [1.65, 6.99]**
Heterogeneity: Tau² = 4.81; Chi² = 22.70, df = 2 (P < 0.0001); I² = 91%				
Test for overall effect: Z = 3.18 (P = 0.001)				
1.2.2 Mid SS				
Hartman, 21	1.7	0.7	12.3%	1.70 [0.33, 3.07]
Liu, 17	-1.12	0.2	12.7%	-1.12 [-1.51, -0.73]
Samady, 11	-0.13	1.4	11.4%	-0.13 [-2.87, 2.61]
Subtotal (95% CI)			**36.3%**	**0.11 [-2.00, 2.23]**
Heterogeneity: Tau² = 2.83; Chi² = 15.31, df = 2 (P = 0.0005); I² = 87%				
Test for overall effect: Z = 0.10 (P = 0.92)				
1.2.3 High SS				
Hartman, 21	0.2	0.7	12.3%	0.20 [-1.17, 1.57]
Liu, 17	-2.23	4.3	6.0%	-2.23 [-10.66, 6.20]
Samady, 11	-1.34	2.6	9.0%	-1.34 [-6.44, 3.76]
Subtotal (95% CI)			**27.3%**	**0.04 [-1.27, 1.35]**
Heterogeneity: Tau² = 0.00; Chi² = 0.61, df = 2 (P = 0.74); I² = 0%				
Test for overall effect: Z = 0.06 (P = 0.95)				
Total (95% CI)			**100.0%**	**1.36 [-1.48, 4.20]**
Heterogeneity: Tau² = 16.54; Chi² = 436.95, df = 8 (P < 0.00001); I² = 98%				
Test for overall effect: Z = 0.94 (P = 0.35)				
Test for subgroup differences: Chi² = 8.36, df = 2 (P = 0.02), I² = 76.1%				



Impact of WSS on change in plaque burden (%)

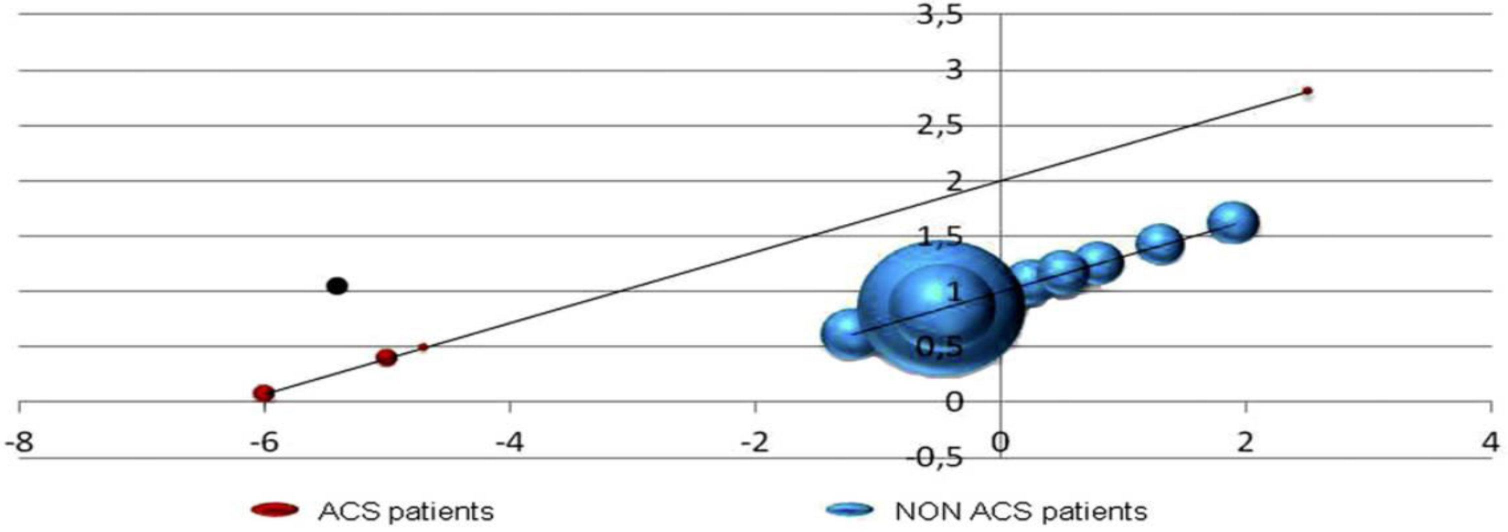
Study or Subgroup	Mean Difference	SE	Weight	Mean Difference IV, Random, 95% CI
1.2.1 low SS				
Hung, 16	-1.17	0.3	10.9%	-1.17 [-1.76, -0.58]
Liu, 17	-0.79	0.16	12.5%	-0.79 [-1.10, -0.48]
Samady, 11	-0.9	0.33	10.5%	-0.90 [-1.55, -0.25]
Subtotal (95% CI)			**34.0%**	**-0.88 [-1.13, -0.62]**
Heterogeneity: Tau² = 0.00; Chi² = 1.25, df = 2 (P = 0.53); I² = 0%				
Test for overall effect: Z = 6.77 (P < 0.00001)				
1.2.2 mid SS				
Hung, 16	-0.64	0.3	10.9%	-0.64 [-1.23, -0.05]
Liu, 17	0.09	0.03	13.3%	0.09 [0.03, 0.15]
Samady, 11	0	0.4	9.6%	0.00 [-0.78, 0.78]
Subtotal (95% CI)			**33.8%**	**-0.14 [-0.61, 0.34]**
Heterogeneity: Tau² = 0.11; Chi² = 5.91, df = 2 (P = 0.05); I² = 66%				
Test for overall effect: Z = 0.57 (P = 0.57)				
1.2.3 High SS				
Hung, 16	0.61	0.4	9.6%	0.61 [-0.17, 1.39]
Liu, 17	1.01	0.1	13.0%	1.01 [0.81, 1.21]
Samady, 11	0.3	0.4	9.6%	0.30 [-0.48, 1.08]
Subtotal (95% CI)			**32.2%**	**0.78 [0.34, 1.21]**
Heterogeneity: Tau² = 0.08; Chi² = 3.72, df = 2 (P = 0.16); I² = 46%				
Test for overall effect: Z = 3.50 (P = 0.0005)				
Total (95% CI)			**100.0%**	**-0.16 [-0.62, 0.30]**
Heterogeneity: Tau² = 0.41; Chi² = 148.76, df = 8 (P < 0.00001); I² = 95%				
Test for overall effect: Z = 0.69 (P = 0.49)				
Test for subgroup differences: Chi² = 42.81, df = 2 (P < 0.00001), I² = 95.3%				



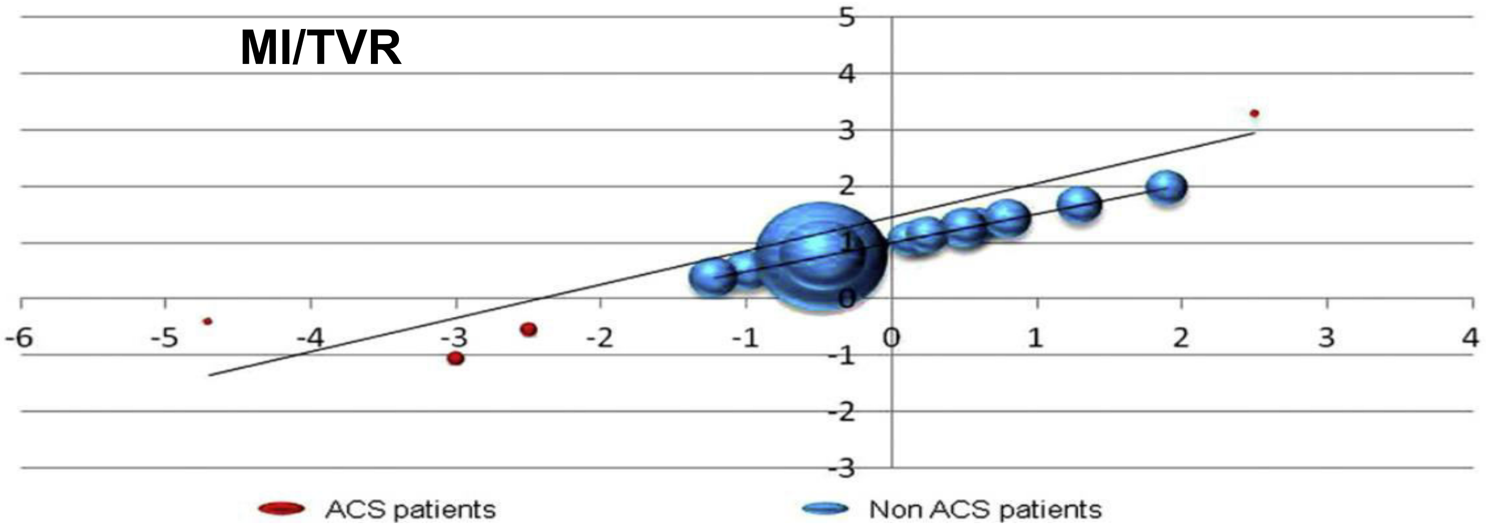
Impact of WSS on change of lumen area (mm^2).

PLAQUE PROGRESSION AND CLINICAL EVENTS

MACE



MI/TVR



D'Ascenzo, Atherosclerosis 13

Atherosclerotic coronary plaque regression and the risk of adverse cardiovascular events: A meta-regression of randomized clinical trials

WSS AND MI

Out of 441 FAME pts
34 (8%) experienced
MI in 4 years

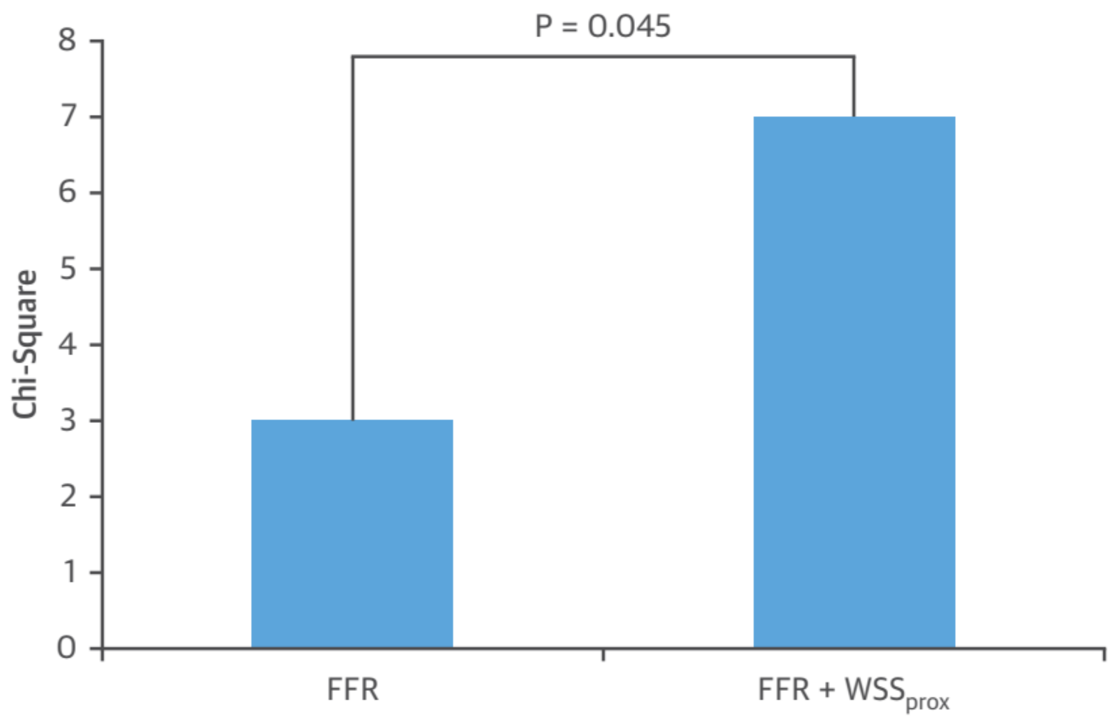
	MI	Non-MI	p Value
Age, yrs	63.1 ± 12.03	61.41 ± 8.94	0.546
Male	23 (79.31)	23 (79.31)	1.000
Body mass index, kg/m^2	28.23 ± 3.55	28.49 ± 4.66	0.994
Current smoker	9 (31.03)	9 (31.03)	1.000
Hypertension	24 (82.76)	24 (82.76)	1.000
Diabetes	11 (37.93)	11 (37.93)	1.000
Hypercholesterolemia	23 (79.31)	26 (89.66)	0.470
Peripheral vascular disease	7 (24.14)	7 (24.14)	1.000
Family history of CAD	15 (51.72)	17 (58.62)	0.792
History of myocardial infarction	11 (37.93)	15 (51.72)	0.429
History of PCI in target vessel	4 (13.79)	6 (20.69)	0.730
History of stroke/TIA	5 (17.24)	3 (10.34)	0.706
LVEF ≤50%	4 (13.79)	3 (10.34)	1.000
Angina class (CCS) (baseline)			0.270
I	4 (13.79)	7 (24.14)	
II	14 (48.28)	10 (34.48)	
III	4 (13.79)	1 (3.45)	
IV	0 (0)	2 (6.9)	
Asymptomatic	7 (24.14)	9 (31.03)	

High Coronary Shear Stress in Patients With Coronary Artery Disease Predicts Myocardial Infarction

Kumar, Jacc 18

WSS AND MI

Distance of lesion MLD from vessel ostium	0.981 (0.954-1.009)	0.187
Distance of proximal segment of lesion from MLD	0.965 (0.905-1.030)	0.285
Lesion length	1.014 (0.980-1.050)	0.430
DS%, per 10% increase	1.374 (1.068-1.767)	0.013
FFR	0.084 (0.006-1.159)	0.064
WSS_{prox}, per 3-Pa increase (adjusted for distance of lesion MLD from vessel ostium)	1.194 (1.022-1.395)	0.025
WSS_{prox}, per 3-Pa increase (adjusted for distance of proximal segment of lesion from MLD)	1.218 (1.060-1.399)	0.005
WSS_{prox}, per 3-Pa increase (adjusted for DS%)	1.183 (1.027-1.363)	0.020
WSS_{prox}, per 3-Pa increase (adjusted for lesion length)	1.229 (1.069-1.413)	0.004
WSS_{prox}, per 3-Pa increase (adjusted for FFR)	1.204 (1.033-1.402)	0.017



High Coronary Shear Stress in Patients With Coronary Artery Disease Predicts Myocardial Infarction

Kumar, Jacc 18

WSS AND CLINICAL EVENTS

23 patients with MACE

122 without

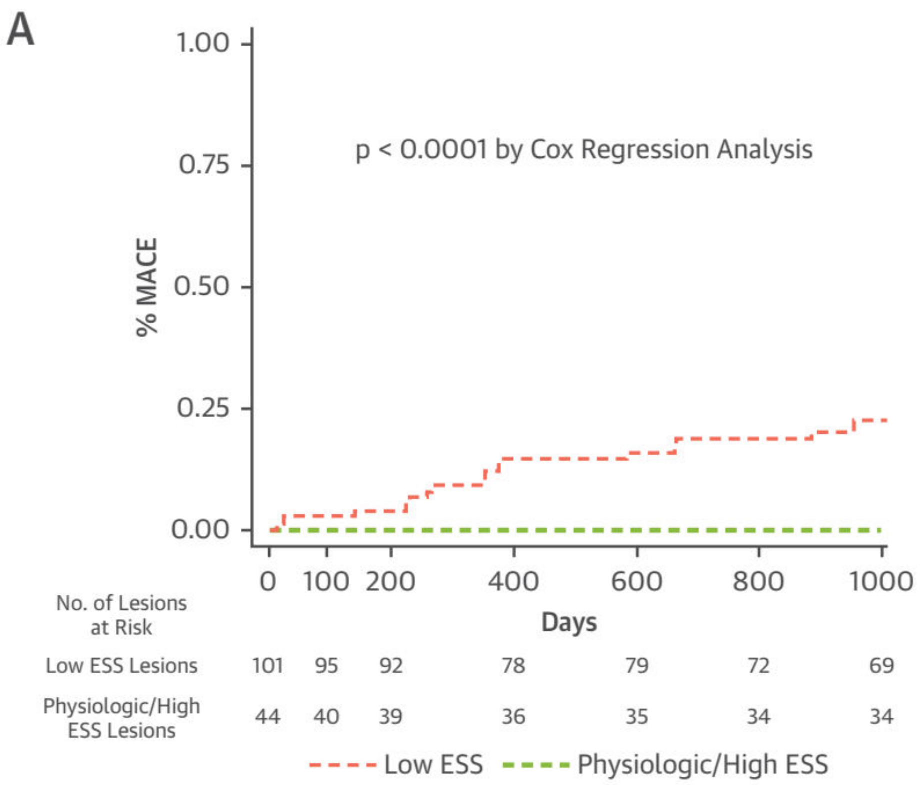
	nc-MACE Lesions (n = 23)	nc-non-MACE Lesions (n = 122)	p Value
Lesion length, mm	33.0 ± 21.0	21.0 ± 12.0	0.02
Plaque burden, %	67.7 ± 8.0	59.0 ± 8.6	<0.001
Minimal lumen area, mm^2	4.2 ± 1.0	5.4 ± 2.0	<0.0001
Lowest local ESS, Pa	0.61 ± 0.34	1.13 ± 0.79	<0.0001
Highest local ESS, Pa	6.02 ± 2.95	4.69 ± 2.44	0.12
EEM area, mm^2	14.44 ± 3.50	14.11 ± 4.47	0.78
Lumen area, mm^2	6.66 ± 1.52	7.20 ± 2.41	0.31
Plaque area, mm^2	7.78 ± 2.29	6.91 ± 2.49	0.22
Arterial remodeling at the MLA			0.003
Constrictive	14 (60.9)	35 (28.7)	
Compensatory	9 (39.1)	87 (71.3)	
Expansive	0 (0.0)	0 (0.0)	
Artery-specific coronary blood flow, ml/s	1.27 ± 0.50	1.30 ± 1.30	0.81
Thin-cap fibroatheroma	13 (56.5)	63 (51.6)	0.67
Thick-cap fibroatheroma	10 (43.5)	59 (48.4)	0.67
Coronary artery			0.97
Left anterior descending	8 (34.8)	42 (34.4)	
Left circumflex	8 (34.8)	40 (32.8)	
Right	7 (30.4)	40 (32.8)	
Location in artery			0.25
Proximal	15 (65.2)	59 (48.4)	
Middle	6 (26.0)	37 (30.3)	
Distal	2 (8.7)	26 (21.3)	

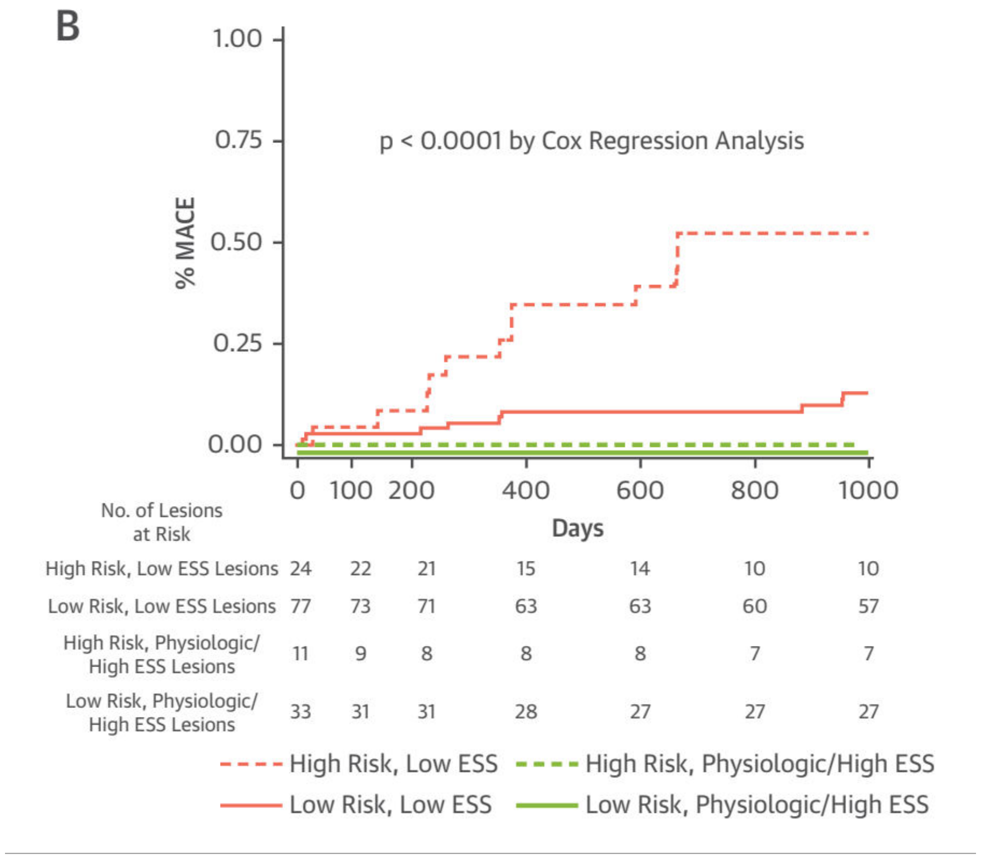
Role of Low Endothelial Shear Stress and Plaque Characteristics in the Prediction of Nonculprit Major Adverse Cardiac Events

The PROSPECT Study

Stone, Jacc 18

WSS AND CLINICAL EVENTS





Role of Low Endothelial Shear Stress and Plaque Characteristics in the Prediction of Nonculprit Major Adverse Cardiac Events

The PROSPECT Study

Stone, Jacc 18

WSS AND MINOCA

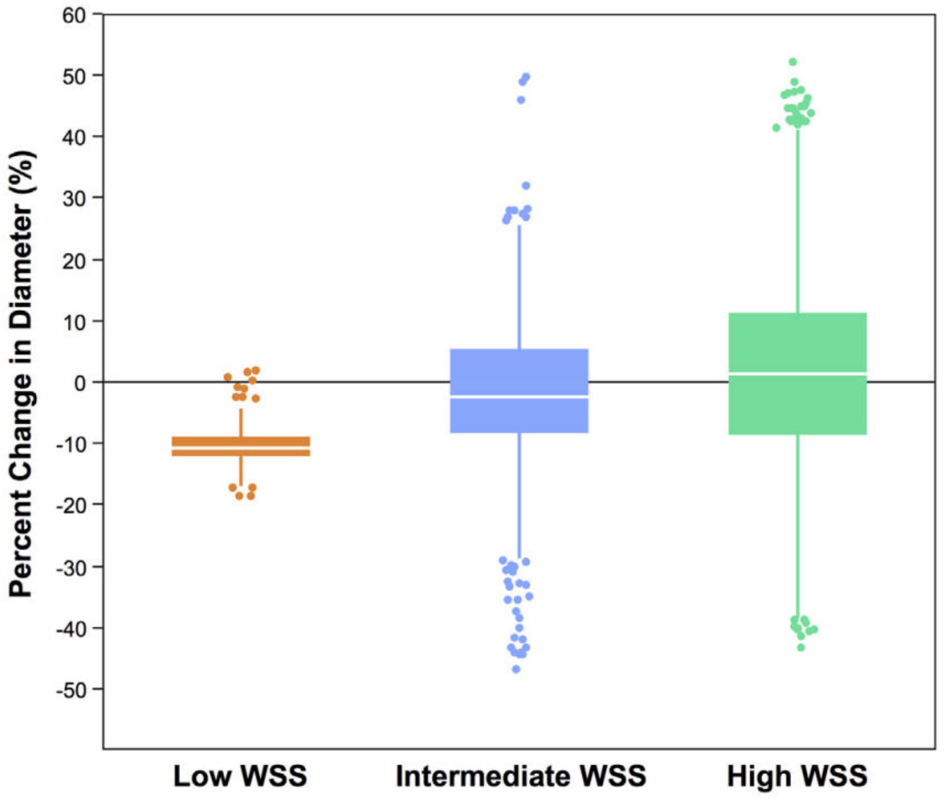
54 pts with MINOCA

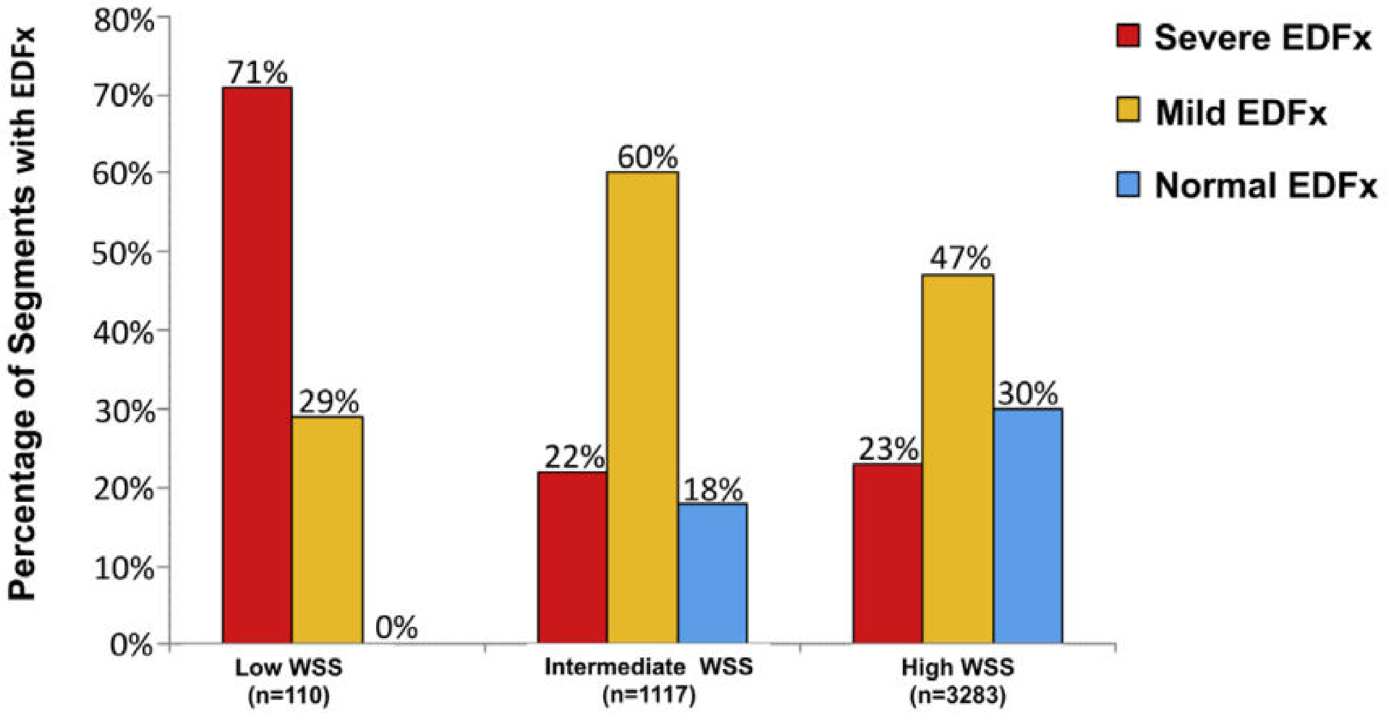
Age (yrs)	52.0 (44.0-66.0)
Female	32 (73)
African American	24 (55)
Cardiovascular risk factors	
Hypertension	13 (30)
Diabetes mellitus	1 (2)
Hyperlipidemia	20 (45)
Current smoker	3 (7)
Medication use	
Aspirin	23 (52)
$P2Y_{12}$ inhibitor	5 (11)
Statin	20 (45)
Beta-blocker	16 (36)
Calcium-channel blocker	9 (20)
Long-acting nitrate	10 (23)
ACE inhibitor or ARB	10 (23)

Low Coronary Wall Shear Stress Is Associated With Severe Endothelial Dysfunction in Patients With Nonobstructive Coronary Artery Disease

Kumar, Jacc 18

WSS AND MINOCA





Kumar, Jacc 18

Low Coronary Wall Shear Stress Is Associated With Severe Endothelial Dysfunction in Patients With Nonobstructive Coronary Artery Disease

TAKE HOME MESSAGES

WSS has a clear physio pathologic background

Its role in plaque progression has been demonstrated

Challenges in avaibility in the cath lab may limit clinical impact


"That's all Folks!"