L'UTILISATION JUDICIEUSE DES EXAMENS EN CARDIOLOGIE

Stratification coronarienne non-invasive

22 novembre 2024

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Objectifs

- Évaluer la probabilité pré-test de MCAS et discuter de l'utilisation pertinente d'outils de stratification non invasive coronarienne à des fins de diagnostic
- Connaître les modalités de stratification coronarienne à notre disposition et leur applicabilité en clinique
- Discuter des indications et modalités de réévaluation coronarienne non invasive chez le patient connu pour une MCAS

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Conflit d'intérêt:

- Aucun (outre un intérêt pour l'échographie de stress)

Autre divulgation:

- Spécialiste en maladies congénitales ≠ Expert de la MCAS
- Présentation d'un cardiologue général à tous les professionnels qui prennent soins de ces patients

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Plan de la présentation

- Clin d'œil à l'évolution des modalités diagnostiques
- Les DRS de Mme Tremblay
    - -Probabilité pré test de MCAS et son influence sur l'investigation
    - -Les modalités de stratification et les considérations associées
- Le retour de Mme Tremblay
    - -L'évaluation des DRS sans maladie épicardique significative
- La stabilité de Mme Tremblay
    - -L'utilisation d'épreuve de stratification au suivi du patient coronarien

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Un coffre à outil qui s'est rempli

1934
ECG d'effort

1958
Première coronarographie

~ 1970
Image de perfusion myocardique

~ 1980
Échographie de stress
Effort

~ 1980
«Gated» SPECT
Introduction de la vasodilatation

~ 1990
Échographie de stress
Dobutamine

~ 1990
Perfusion via TEP
Introduction de la viabilité

~ 2000
TEP – évaluation du flot myocardique et de la réserve

~ 2000
Imagerie coronarienne
CT multicoupe

~ 2015
IRM de stress

2010
Évaluation hémodynamique
Intracoronarienne

2016
Imagerie intracoronarienne

2018
Évaluation physiologique
intracoronarienne

2019
Évaluation
hémodynamique au
CT coronarien

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Les DRS de Mme Tremblay

Patiente de 62 ans

Référée pour DRS

DRS x 6 mois, souvent à l'effort, aussi parfois au repos et réveille occasionnellement la nuit. Durée de 15-30 min.

TA 137/90 mmHg, FC 60, IMC 36

Examen physique sans particularité

Agente de bureau

Pas de tabac

RX:

Telmisartan 80 mg

MCAS père – IDM 55 ans

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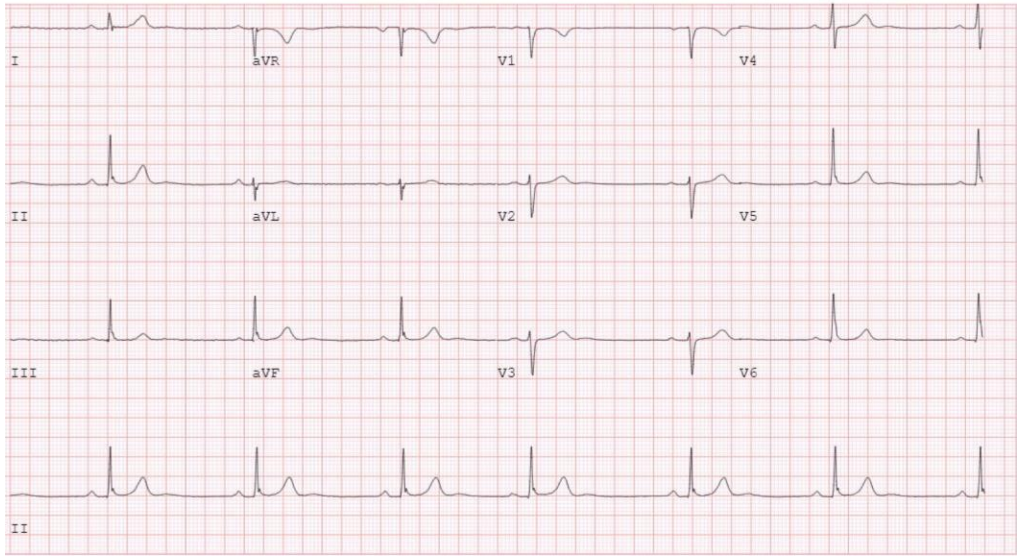

HB 134

Créatinine 83

LDL 3,2

HDL 1.0

Non-HDL 2.8

Apo B 0.9

HBA1c 5.6%

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Que souhaitez-vous faire ensuite pour Mme Tremblay?

a) Échographique de stress sur tapis roulant
b) Mibi Persantin
c) Tapis Roulant
d) TEP rubidium
e) Coronarographie
f) Je n'ai pas écouté l'énoncé du cas et je m'abstiens

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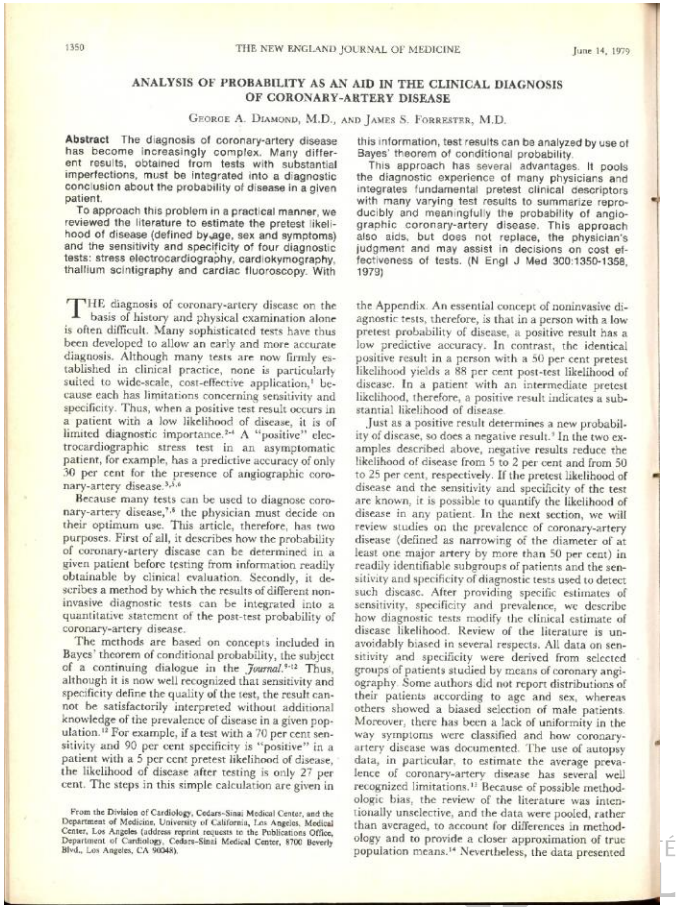
Évaluation de la probabilité de MCAS

→ Dérive de données de patients référés pour coronarographie

→ Ne reflète plus la population référée pour évaluation non-invasive

→ Prévalence plus faible – 5.1% des DRS à l'urgence sont des SCA, > 50% sont non cardiaques



1350 THE NEW ENGLAND JOURNAL OF MEDICINE June 14, 1979

ANALYSIS OF PROBABILITY AS AN AID IN THE CLINICAL DIAGNOSIS OF CORONARY-ARTERY DISEASE

GEORGE A. DIAMOND, M.D., AND JAMES S. FORRESTER, M.D.

Abstract The diagnosis of coronary-artery disease has become increasingly complex. Many different results, obtained from tests with substantial imperfections, must be integrated into a diagnostic conclusion about the probability of disease in a given patient.

To approach this problem in a practical manner, we reviewed the literature to estimate the pretest likelihood of disease (defined by age, sex and symptoms) and the sensitivity and specificity of four diagnostic tests: stress electrocardiography, cardiokymography, thallium scintigraphy and cardiac fluoroscopy. With this information, test results can be analyzed by use of Bayes' theorem of conditional probability.

This approach has several advantages. It pools the diagnostic experience of many physicians and integrates fundamental pretest clinical descriptors with many varying test results to summarize reproducibly and meaningfully the probability of angiographic coronary-artery disease. This approach also aids, but does not replace, the physician's judgment and may assist in decisions on cost effectiveness of tests. (N Engl J Med 300:1350-1358, 1979)

THE diagnosis of coronary-artery disease on the basis of history and physical examination alone is often difficult. Many sophisticated tests have thus been developed to allow an early and more accurate diagnosis. Although many tests are now firmly established in clinical practice, none is particularly suited to wide-scale, cost-effective application,[1] because each has limitations concerning sensitivity and specificity. Thus, when a positive test result occurs in a patient with a low likelihood of disease, it is of limited diagnostic importance.[2-4] A "positive" electrocardiographic stress test in an asymptomatic patient, for example, has a predictive accuracy of only 30 per cent for the presence of angiographic coronary-artery disease.[3,5,6]

Because many tests can be used to diagnose coronary-artery disease,[7,8] the physician must decide on their optimum use. This article, therefore, has two purposes. First of all, it describes how the probability of coronary-artery disease can be determined in a given patient before testing from information readily obtainable by clinical evaluation. Secondly, it describes a method by which the results of different noninvasive diagnostic tests can be integrated into a quantitative statement of the post-test probability of coronary-artery disease.

The methods are based on concepts included in Bayes' theorem of conditional probability, the subject of a continuing dialogue in the *Journal*.[9-12] Thus, although it is now well recognized that sensitivity and specificity define the quality of the test, the result cannot be satisfactorily interpreted without additional knowledge of the prevalence of disease in a given population.[12] For example, if a test with a 70 per cent sensitivity and 90 per cent specificity is "positive" in a patient with a 5 per cent pretest likelihood of disease, the likelihood of disease after testing is only 27 per cent. The steps in this simple calculation are given in the Appendix. An essential concept of noninvasive diagnostic tests, therefore, is that in a person with a low pretest probability of disease, a positive result has a low predictive accuracy. In contrast, the identical positive result in a person with a 50 per cent pretest likelihood yields a 88 per cent post-test likelihood of disease. In a patient with an intermediate pretest likelihood, therefore, a positive result indicates a substantial likelihood of disease.

Just as a positive result determines a new probability of disease, so does a negative result.[3] In the two examples described above, negative results reduce the likelihood of disease from 5 to 2 per cent and from 50 to 25 per cent, respectively. If the pretest likelihood of disease and the sensitivity and specificity of the test are known, it is possible to quantify the likelihood of disease in any patient. In the next section, we will review studies on the prevalence of coronary-artery disease (defined as narrowing of the diameter of at least one major artery by more than 50 per cent) in readily identifiable subgroups of patients and the sensitivity and specificity of diagnostic tests used to detect such disease. After providing specific estimates of sensitivity, specificity and prevalence, we describe how diagnostic tests modify the clinical estimate of disease likelihood. Review of the literature is unavoidably biased in several respects. All data on sensitivity and specificity were derived from selected groups of patients studied by means of coronary angiography. Some authors did not report distributions of their patients according to age and sex, whereas others showed a biased selection of male patients. Moreover, there has been a lack of uniformity in the way symptoms were classified and how coronary-artery disease was documented. The use of autopsy data, in particular, to estimate the average prevalence of coronary-artery disease has several well recognized limitations.[13] Because of possible methodologic bias, the review of the literature was intentionally unselective, and the data were pooled, rather than averaged, to account for differences in methodology and to provide a closer approximation of true population means.[14] Nevertheless, the data presented

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Hsia et al, JAMA 2016

Évaluation de la probabilité de MCAS

Ne tient pas compte des facteurs de risque ni des symptômes atypiques – incluant la dyspnée

Table 1. Prevalence of Angiographic Coronary-Artery Disease in Symptomatic Patients.

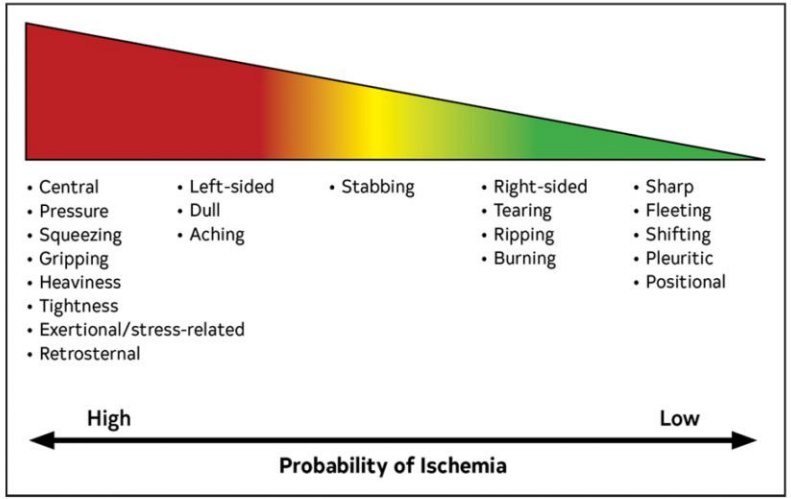
Symptom	Proportion of Patients Affected	Pooled Mean ± SEP* (%)
Nonanginal chest pain	146/913	16.0±1.2
Atypical angina	963/1931	49.9±1.1
Typical angina	1874/2108	88.9±0.7

*Standard error of the per cent (see the Appendix). These values establish statistical levels of error but do not include errors due to sampling bias & other factors, which are probably of greater magnitude.

1.4.2. Defining Chest Pain

Recommendations for Defining Chest Pain
Referenced studies that support the recommendations are summarized in Online Data Supplements 1 and 2.

COR	LOE	Recommendations
1	B-NR	1. An initial assessment of chest pain is recommended to triage patients effectively on the basis of the likelihood that symptoms may be attributable to myocardial ischemia.[1-7]
1	C-LD	2. Chest pain should not be described as atypical, because it is not helpful in determining the cause and can be misinterpreted as benign in nature. Instead, chest pain should be described as cardiac, possibly cardiac, or noncardiac because these terms are more specific to the potential underlying diagnosis.



Gulati et al, circulation 2021

Les symptômes atypiques: femmes

2.1.1. A Focus on the Uniqueness of Chest Pain in Women

Recommendations for a Focus on the Uniqueness of Chest Pain in Women Referenced studies that support the recommendations are summarized in Online Data Supplements 3 and 4.		
COR	**LOE**	**Recommendations**
1	B-NR	1. Women who present with chest pain are at risk for underdiagnosis, and potential cardiac causes should always be considered.[1-7]
1	B-NR	2. In women presenting with chest pain, it is recommended to obtain a history that emphasizes accompanying symptoms that are more common in women with ACS.[1-7]

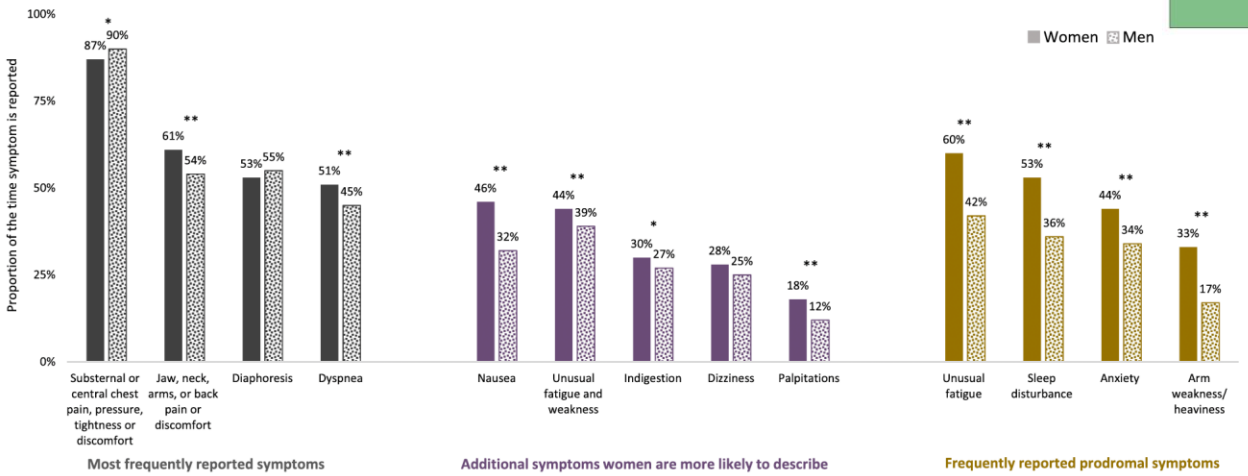


Figure 4. Symptoms commonly reported by those presenting with ischemic heart disease, women vs men. * $P < 0.05$; ** $P < 0.01$.

Pacheo et al., CJC 2022
Gulati et al, circulation 2021

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Les symptômes atypiques – patients âgés

2.1.2. Considerations for Older Patients With Chest Pain

Recommendation for Considerations for Older Patients With Chest Pain		
COR	**LOE**	**Recommendation**
1	**C-LD**	1. In patients with chest pain who are >75 years of age, ACS should be considered when accompanying symptoms such as shortness of breath, syncope, or acute delirium are present, or when an unexplained fall has occurred.[1]

- Prévalence plus élevée de MCAS chez les > 75 ans - 33% des SCA
- Comorbidité plus fréquente; la DRS demeure plus souvent de cause alternative

Gupta et al., Emerg Med Clin North Am. 2016
Jokhadar et al., Clin Interv Aging. 2009
Gulati et al, circulation 2021

Age, Years	Chest Pain Criteria 1. Substernal chest discomfort with characteristic quality and duration 2. Provoked by exertion or emotional stress 3. Relieved promptly by rest or nitroglycerin					
	Nonanginal Chest Pain 1 of 3 Criteria		Atypical Angina 2 of 3 Criteria		Typical Angina 3 of 3 Criteria	
	Male	Female	Male	Female	Male	Female
30 – 39	4%	2%	34%	12%	76%	26%
40 - 49	13%	3%	51%	22%	87%	55%
50 - 59	20%	7%	65%	33%	93%	73%
60 - 69	27%	14%	72%	51%	94%	86%

Guidelines Canadiens

→Dérive de l'étude de 1979 et de la cohorte CONFIRM…

- Investigation suggérée lorsque probabilité pré-test > 15%
- Considération des modificateurs entre 5-15%
- Éviter lorsque moins de 5%

Table 5 Pre-test probabilities of obstructive coronary artery disease in 15 815 symptomatic patients according to age, sex, and the nature of symptoms in a pooled analysis[64] of contemporary data[7,8,62]

	Typical		Atypical		Non-anginal		Dyspnoea[a]	
Age	Men	Women	Men	Women	Men	Women	Men	Women
30–39	3%	5%	4%	3%	1%	1%	0%	3%
40–49	22%	10%	10%	6%	3%	2%	12%	3%
50–59	32%	13%	17%	6%	11%	3%	20%	9%
60–69	44%	16%	26%	11%	22%	6%	27%	14%
70+	52%	27%	34%	19%	24%	10%	32%	12%

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CAD = coronary artery disease; PTP = pre-test probability.

[a]In addition to the classic Diamond and Forrester classes,[59] patients with dyspnoea only or dyspnoea as the primary symptom are included. The regions shaded dark green denote the groups in which non-invasive testing is most beneficial (PTP >15%). The regions shaded light green denote the groups with PTPs of CAD between 5–15%, in which testing for diagnosis may be considered after assessing the overall clinical likelihood based on the modifiers of PTPs presented in *Figure* 3.

Mancini et al., CJC 2014
Knuuti et al., EHJ 2019
Cheng et al., Circ 2011

Pretest Probabilities of Obstructive CAD in Symptomatic Patients
(A) according to age, sex, and symptoms;
(B) according to age, sex, symptoms, and CAC

Age, y	Chest Pain		Dyspnea	
	Men	Women	Men	Women
30–39	≤4	≤5	0	3
40–49	≤22	≤10	12	3
50–59	≤32	≤13	20	9
60–69	≤44	≤16	27	14
70+	≤52	≤27	32	12

- AHA Chest pain guidelines 2021
- Cohortes Européenne de 2019 de 15 000 patients et Américaines de 41 000 patients
- Flexibilité sur l'évaluation de la DRS
- Implication des facteurs de risque demeure limitée

Gulati et al, circulation 2021

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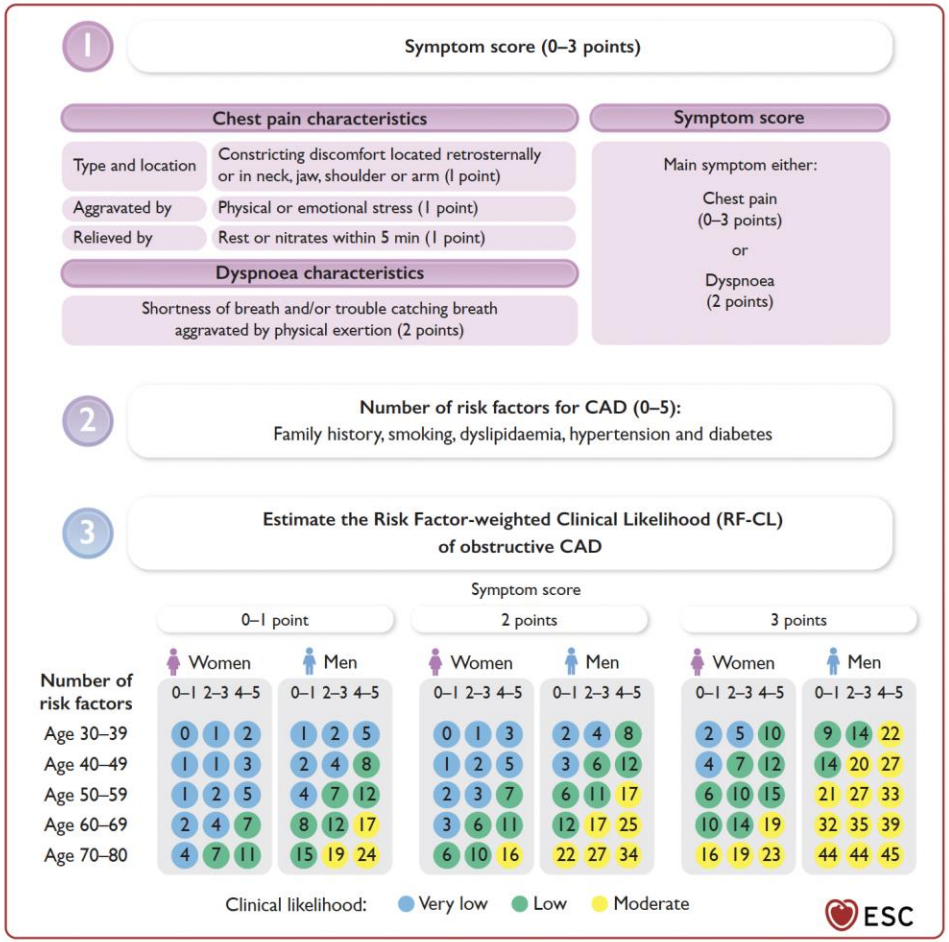

- ESC 2024
- Grade IIa : ne pas faire d'investigation lorsque moins de 5%
- 5-15% : considérer un score calcique pour reclassification
- >15%: investigation non invasive

Vrints et al., EHJ 2024

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Si on applique cela à Mme Tremblay:

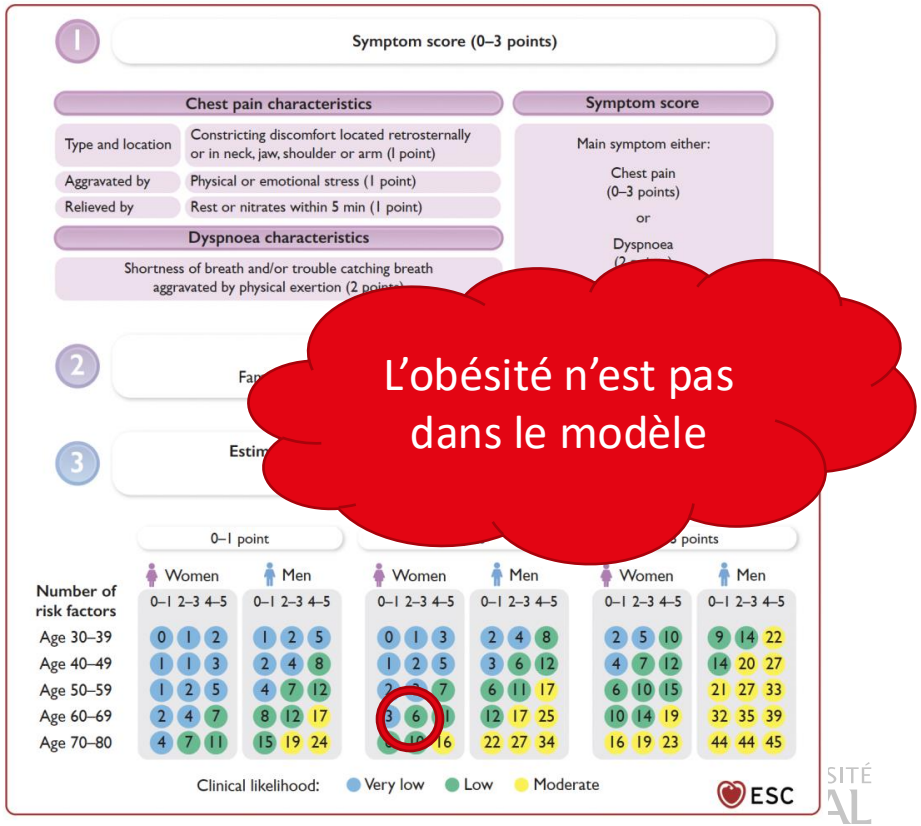
Pretest Probabilities of Obstructive CAD in Symptomatic Patients
(A) according to age, sex, and symptoms;
(B) according to age, sex, symptoms, and CAC

Age, y	Chest Pain		Dyspnea	
	Men	Women	Men	Women
30–39	≤4	≤5	0	3
40–49	≤22	≤10	12	3
50–59	≤32	≤13	20	9
60–69	≤44	≤16	27	14
70+	≤52	≤27	32	12

A **Pretest probability based on age, sex, and symptoms** — Low ≤15% | Intermediate–High >15%

B **Pretest probability based on age, sex, symptoms, and CAC score†** — ≤15% | >15%–50% | >50%

CAC 1–99 | CAC ≥100–999 | CAC ≥1,000



On décide de faire un examen de stratification non invasive Lequel maintenant?

Table 2. Noninvasive test sensitivity and specificity for the diagnosis of obstructive coronary artery disease*

	Sensitivity	Specificity	Reference
Ischemia testing			
Exercise treadmill stress test (Supplememtal Fig. S1)	68%	77%	109,110
Single photon emission computed tomography (Tc-99m SPECT) (Supplemental Fig. S2)	88%	77%-85%	76,109,111
Stress echocardiography (Supplemental Fig. S3)	76%-85%	75%-89%	109,111,112
Positron emission tomography	90%-91%	82%-88%	76,109
Cardiac MRI (Supplemental Fig. S4)			113
•Perfusion	89%	80%	
•Wall motion	83%	86%	
Anatomic testing			
Coronary CT angiography (Supplemental Fig. S5)	94%-99%	79%-88%	114,115

CT, computed tomography; MRI, magnetic resonance imaging; SPECT, single-photon emission computed tomography.

*Obstructive coronary artery disease as defined by invasive coronary angiography.Examples of abnormal tests are provided as supplemental figures.

Chow et al., CJC 2023

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Épreuve d'effort sur tapis roulant

The enduring nature of this investigation is tied to its simplicity, availability, low cost, and ease of correlation with patients' symptoms…

2a	B-R

4. For intermediate-high risk patients with stable chest pain and no known CAD with an interpretable ECG and ability to achieve maximal levels of exercise (≥5 METs), exercise electrocardiography is reasonable.[8,13,15,40-45]

- Demeure un outil pronostique
- Aide à prévoir l'urgence d'investigation subséquente

Recommendation Table 5 — Recommendations for exercise ECG in the initial diagnostic management of individuals with suspected chronic coronary syndrome (see also Evidence Table 5)

Recommendations	Class[a]	Level[b]
Exercise ECG is recommended in selected patients[c] for the assessment of exercise tolerance, symptoms, arrhythmias, BP response, and event risk.	I	C
Exercise ECG may be considered as an alternative test to rule in and rule out CAD when non-invasive imaging tests are unavailable.[148,166,188,190,191]	IIb	B
An exercise ECG may be considered to refine risk stratification and treatment.[188]	IIb	B
In individuals with a low (>5%–15%) pre-test likelihood of obstructive CAD, an exercise ECG may be considered to identify patients in whom further testing can be deferred.[144]	IIb	C
Exercise ECG is not recommended for diagnostic purposes in patients with ≥0.1 mV ST-segment depression on resting ECG, left bundle branch block or who are being treated with digitalis.	III	C
In individuals with a low or moderate (>5%–50%) pre-test likelihood of obstructive CAD, an exercise ECG is not recommended to rule out CAD if CCTA or functional imaging tests are available.[148]	III	C

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Gulati et al, circulation 2021
Vrints et al., EHJ 2024

Échographie de stress

Effort

- Tapis roulant
- Ergocycle

Modalité de choix lorsque faisable

Δ Sens/Spec:

BBG, ARC de base, ESVs

Échogénicité

Inotrope/chronotrope

Dobutamine

Potentiel de réponse chronotrope

- Cessation bêta-bloquant
- CI Atropine (glaucome)
- Pacemaker dépendant

Potentiel arythmique

Δ Sens/Spec:

BBG, ARC de base, ESVs

Vasodilatation

Adénosine/dipyridamole

Peu utilisé en Amérique du Nord

Pellikka et al., JASE, 2020

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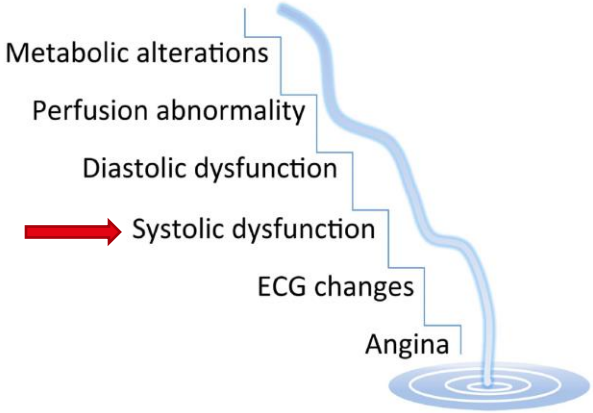
Échographie de stress

Examen sécuritaire, accessible peu couteux

Sensibilité et spécificité ~ 85 et 77%

Évaluation de cause alternative de dyspnée

- Fonction ventriculaire et valvulaire
- Fonction diastolique à l'effort
- Fonction valvulaire à l'effort et PAP
- Viabilité avec la dobutamine



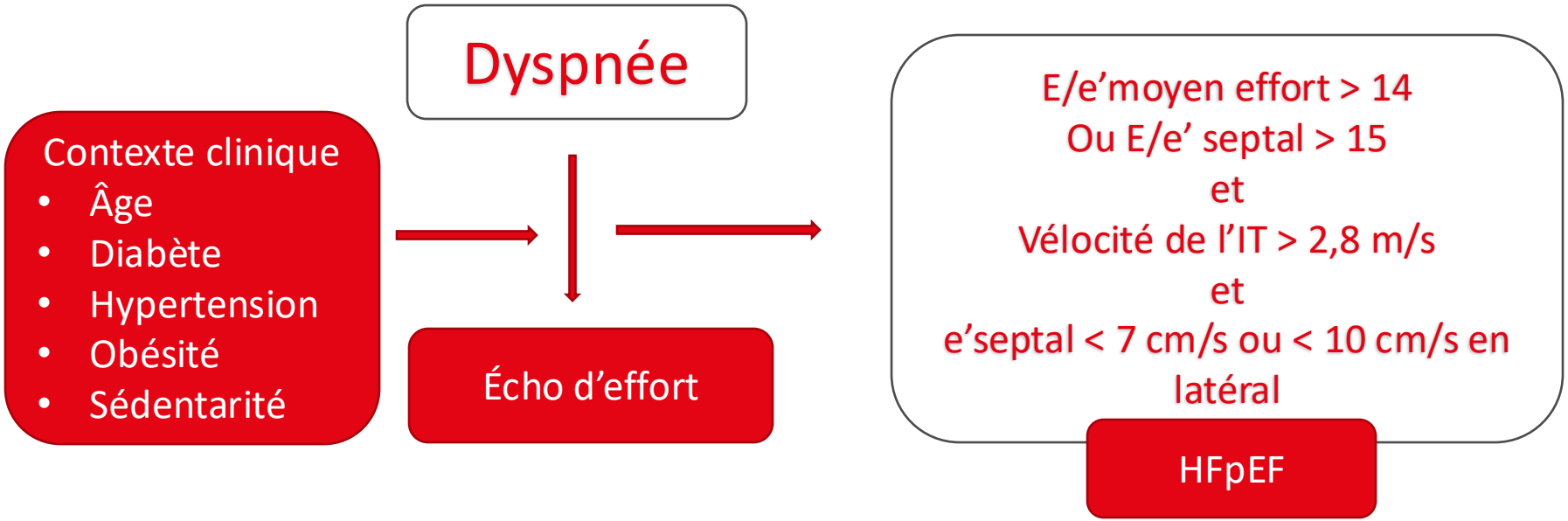
Recommendations	Class[a]	Level[b]
In individuals with suspected CCS and moderate or high (>15%–85%) pre-test likelihood of obstructive CAD, stress echocardiography is recommended to diagnose myocardial ischaemia and to estimate the risk of MACE.[33,241–246]	I	B

Stress Testing

1	B-R	2. For intermediate-high risk patients with stable chest pain and no known CAD, stress imaging (stress echocardiography, PET/SPECT MPI or CMR) is effective for diagnosis of myocardial ischemia and for estimating risk of MACE.[8,13-35]

Pellikka et al., JASE, 2020
Gulati et al, circulation 2021
Vrints et al., EHJ 2024

Fonction diastolique à l'effort



Lancellotti et al., JASE 2017

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Médecine nucléaire

SPECT MPI

Effort

Persantin/ adénosine

Sens/Spec: 88% / 77-85%

- Amélioration spécificité avec « gating » et correction atténuation
- CT faible dose: calcification
- Influencé par IMC patient, rythme de pacemaker et BBG
- Radiation 5-9 mSV

TEP Rubidium

Persantin/ adénosine

Sens/Spec: 90-91% / 72-88%

- Correction atténuation fiable
- Mesure de la réserve coronarienne
- Score calcique
  - Indication de Classe 1
- Pas d'influence de l'IMC du patient
- Radiation 2-3 mSV

Chow et al., CJC 2023

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Recommendations	Class[a]	Lev
In individuals with suspected CCS and moderate or high (>15%–85%) pre-test likelihood of obstructive CAD, stress SPECT or, preferably, PET myocardial perfusion imaging is recommended to: • diagnose and quantify myocardial ischaemia and/or scar; • estimate the risk of MACE; • quantify myocardial blood flow (PET).[33,44,223,257,263,268,270,271,281–288]	I	B

Stress Testing		
1	B-R	2. For intermediate-high risk patients with stable chest pain and no known CAD, stress imaging (stress echocardiography, PET/SPECT MPI or CMR) is effective for diagnosis of myocardial ischemia and for estimating risk of MACE.[8,13-35]
2a	B-R	3. For intermediate-high risk patients with stable chest pain and no known CAD for whom rest/stress nuclear MPI is selected, PET is reasonable in preference to SPECT, if available to improve diagnostic accuracy and decrease the rate of nondiagnostic test results.[36-39]

Gulati et al, circulation 2021
Vrints et al., EHJ 2024

IRM de stress

Indication de classe 1 chez le patient stable avec DRS

Stress par vasodilatation
Adénosine et dipyridamole

- Sens/Spec: 79-91/87-94%
- Diminution des faux négatifs
- Moins de coronarographie non nécessaire
- Évaluation de la fibrose

- Accessibilité limitée
- Pas d'exercice physique possible
- Limitation de l'IRM elle-même

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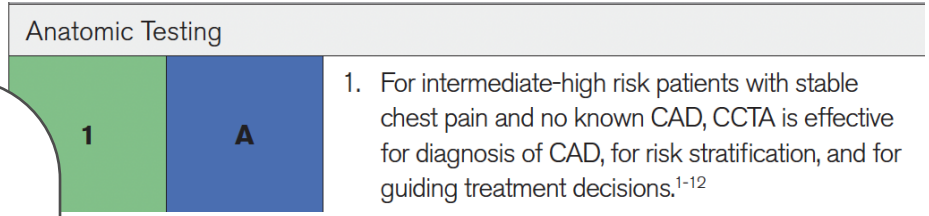
Chow et al., CJC 2023

CT coronaires

- Sens/Spec: 94-99%/ 79-88%
- Détection de MCAS légère
- Intérêt avec étude fonctionnelle +
  - Guider la thérapie, autre dx
- Faible dose de radiation: 3-5 mSv
- Possibilité d'évaluation fonctionnelle
  - FFR_{CT} et CTP



- Expertise milieu dépendant
- Idéal chez le patient de < 65 ans
- Limitations:
  - Calcification extensive
  - Revascularisation percutanée

Gulati et al, circulation 2021
Chow et al., CJC 2023

Le retour de Mme Tremblay

- Vous aviez décidé de référer Mme Tremblay vers une échographique de stress

  Épreuve de 5 min 30, cliniquement et électriquement positive dans 3/12 dérivations à 4 minutes

  Hypokinésie inférieure et inférolatérale au stress

- Coronarographie

  1 tuteur sur la CD, lésion de moins de 30% sur IVA moyenne et une M2

  Revient à l'urgence 2 mois plus tard pour récidive de DRS, pas de nouvelle lésion, tuteur CD bien apposé

- Se retrouve dans votre bureau avec les mêmes malaises….

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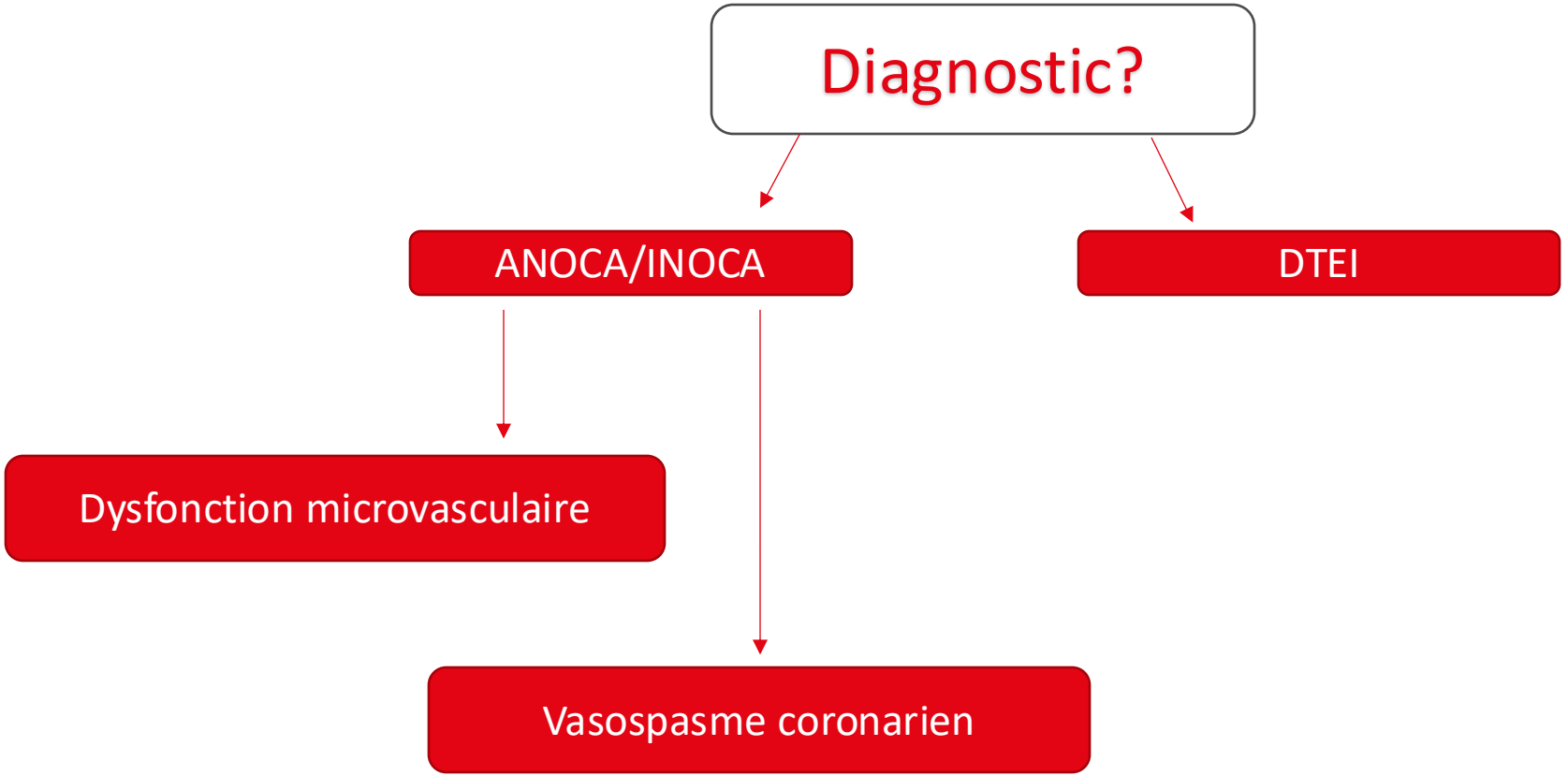

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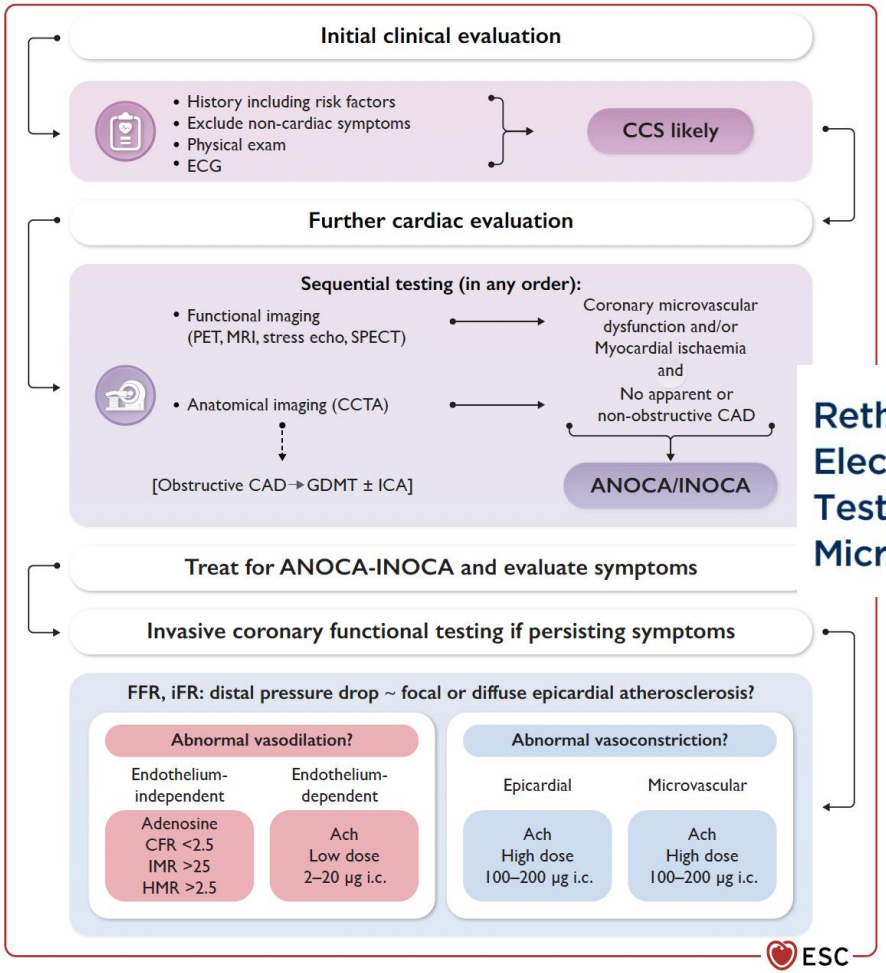

Rethinking False Positive Exercise Electrocardiographic Stress Tests by Assessing Coronary Microvascular Function

Vrints et al., EHJ 2024
Sinha et al., JACC 2024

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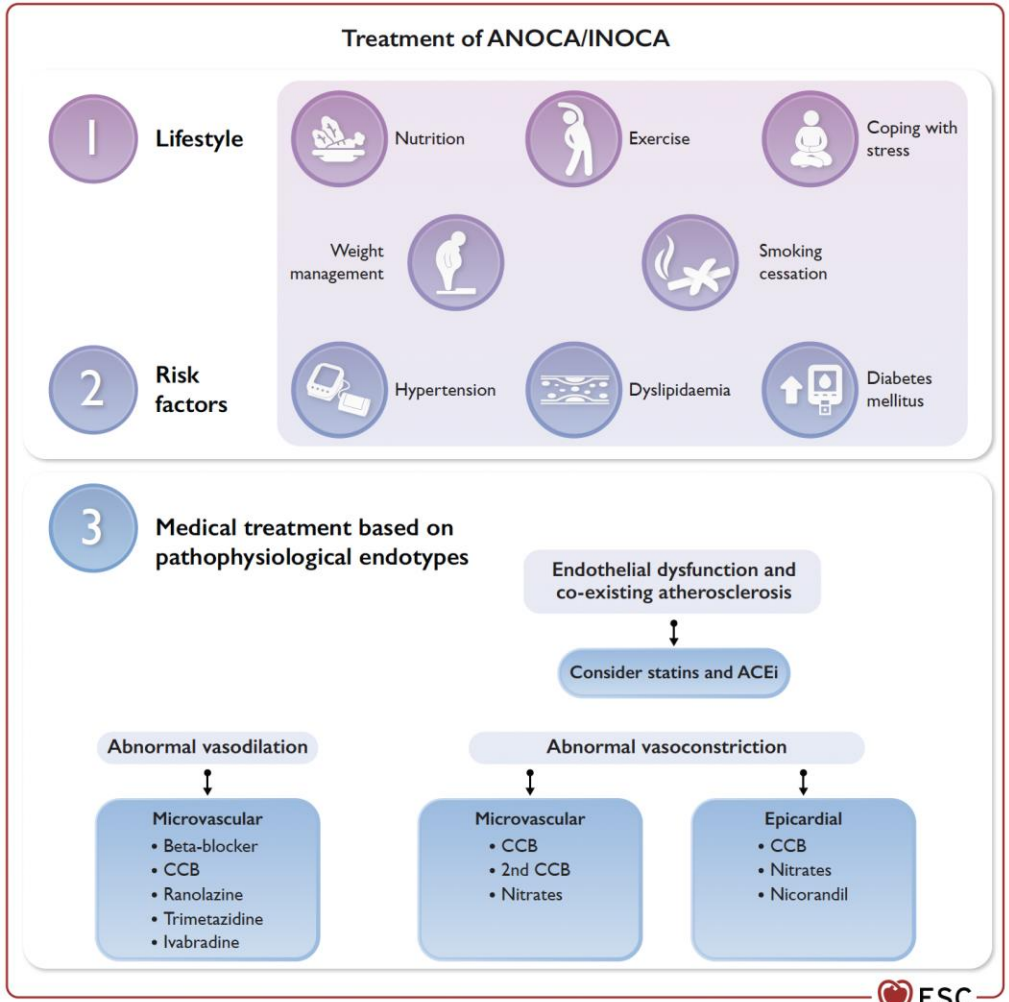

Vrints et al., EHJ 2024

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La stabilité de Mme Tremblay

- Vous faite une TEP rubidium qui démontre une ischémie légère en antérieur et antéroseptal apical avec une réserve légèrement abaissée dans l'IVA à 1.9
- Vous ajoutez un BCC à sa thérapie et elle n'a plus d'angine
- Vous prévoyez la revoir dans 1 an et refaire un bilan de ses facteurs de risque
- La question:

  Mais docteur, mon beau-frère a eu des tuteurs et il a un tapis roulant à chaque année, ne devrais-je pas en avoir un ?

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MCAS stable

Visite clinique annuelle
- Évaluation symptômes, EP
- Comorbidités et FR
- ECG
- Habitudes de vie

Actif et asymptomatique

Examen de suivi non recommandé

Détérioration de la CF ou de l'angine
Diminution de la FEVG

Imagerie fonctionnelle de préférence

Angio-CT des coronaires
- ANOCA/INOCA
- Perméabilité des pontages

3: No benefit	B-R

3. In patients with CCD without a change in clinical or functional status, routine periodic reassessment of LV function is not recommended to guide therapeutic decision-making.[11,12]

Gulati et al, circulation 2021

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Quand est-il de la crainte des patients inactifs et l'ischémie silencieuse?

Les arguments des lignes directrices :

ISCHEMIA trial

Absence de bénéfice de la re
modérée à sévère

CIARIFY registry

Angine associée au MACE ma

POST-PCI trial

Pas de différence entre évaluation fonctionnelle vs soins standard à 2 ans de suivi

→Les problèmes de la vraie vie:

Sédentarité et diminution des activités

Évaluation limitée des symptômes

Gulati et al, circulation 2021

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Conclusions

- Pas d'outil parfait d'évaluation de la probabilité pré-test
  - Prévalence moindre qu'étude initiale et FR à intégrer
- Deux catégories d'examens non invasif
  - Fonctionnel et anatomique
  - A choisir selon le patient et sa présentation clinique
  - Peut être jumelé afin de peaufiner un diagnostic
- Considérer ANOCA dans l'investigation et la prise en charge du patient avec DRS
- Éviter l'examen de stratification systématique dans le suivi du coronarien stable

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Merci!
Questions ?

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