Rôle pronostique du scanner dans le rétrécissement aortique calcifié

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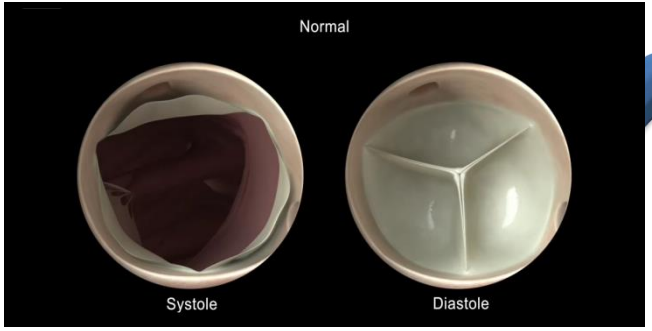
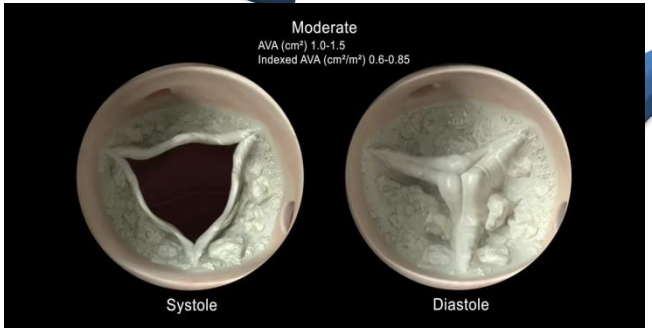
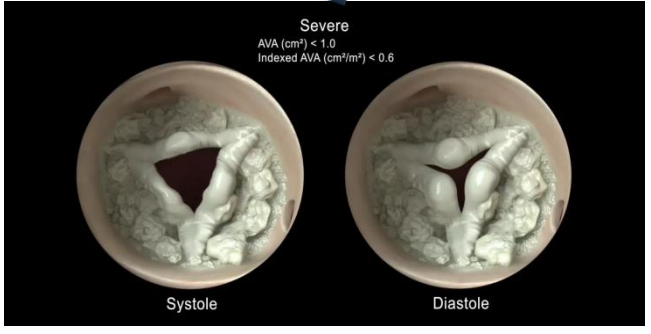
Dépôt progressif de calcium







Sévérité des calcifications en échographie

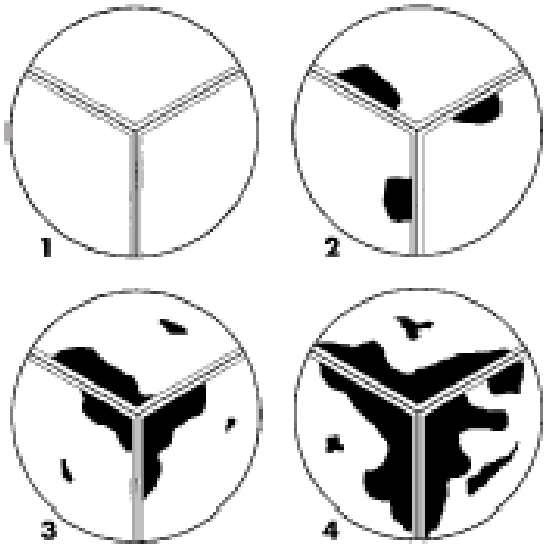
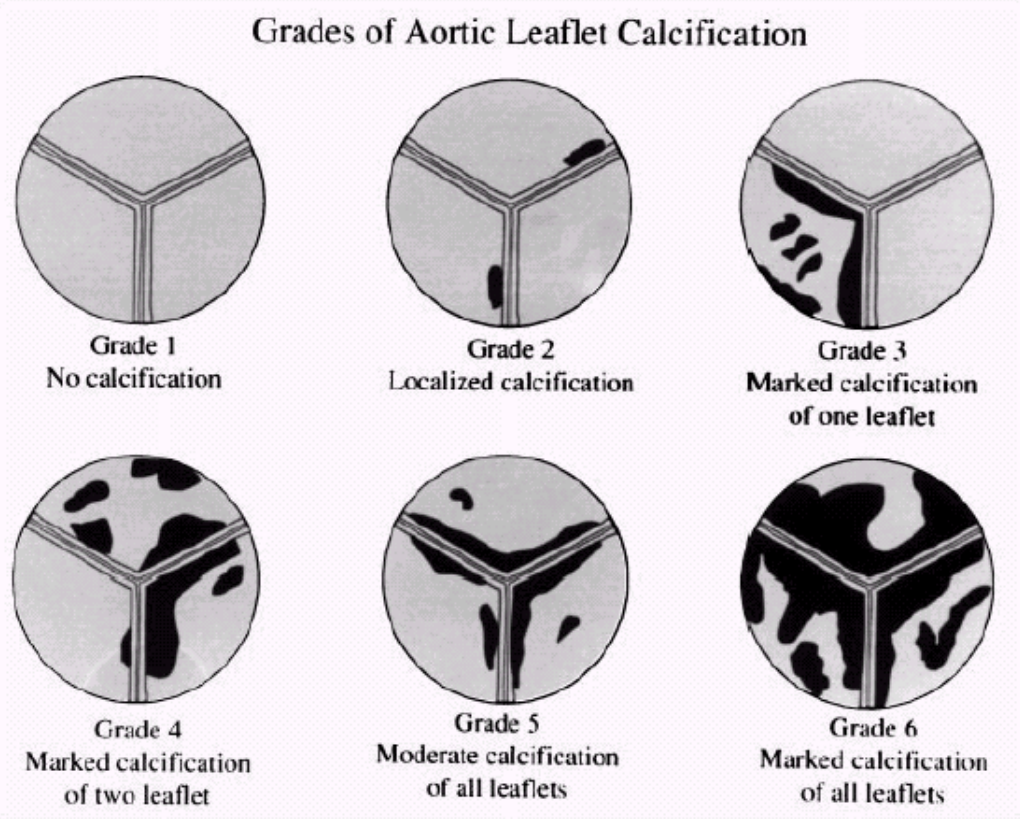
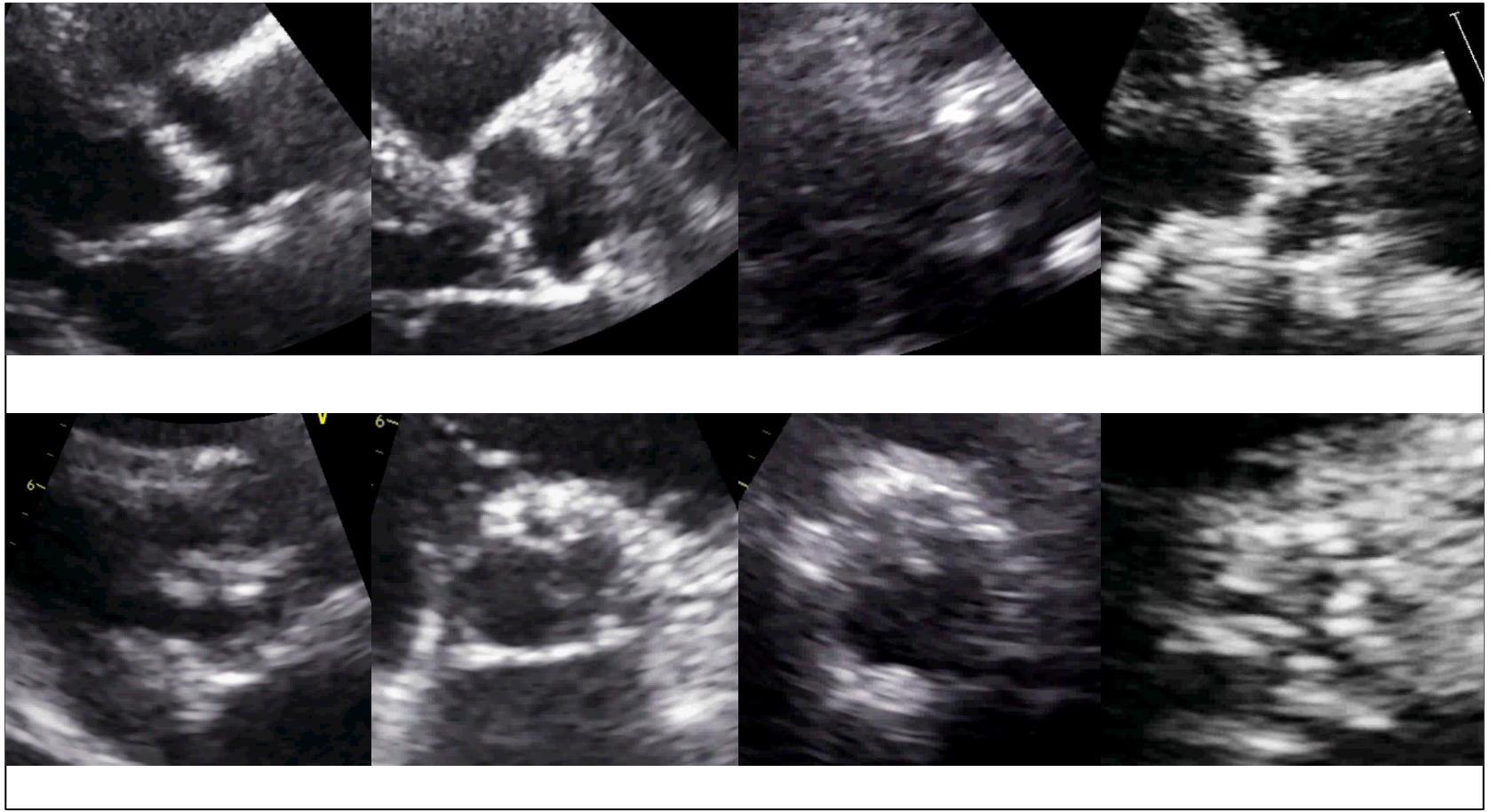


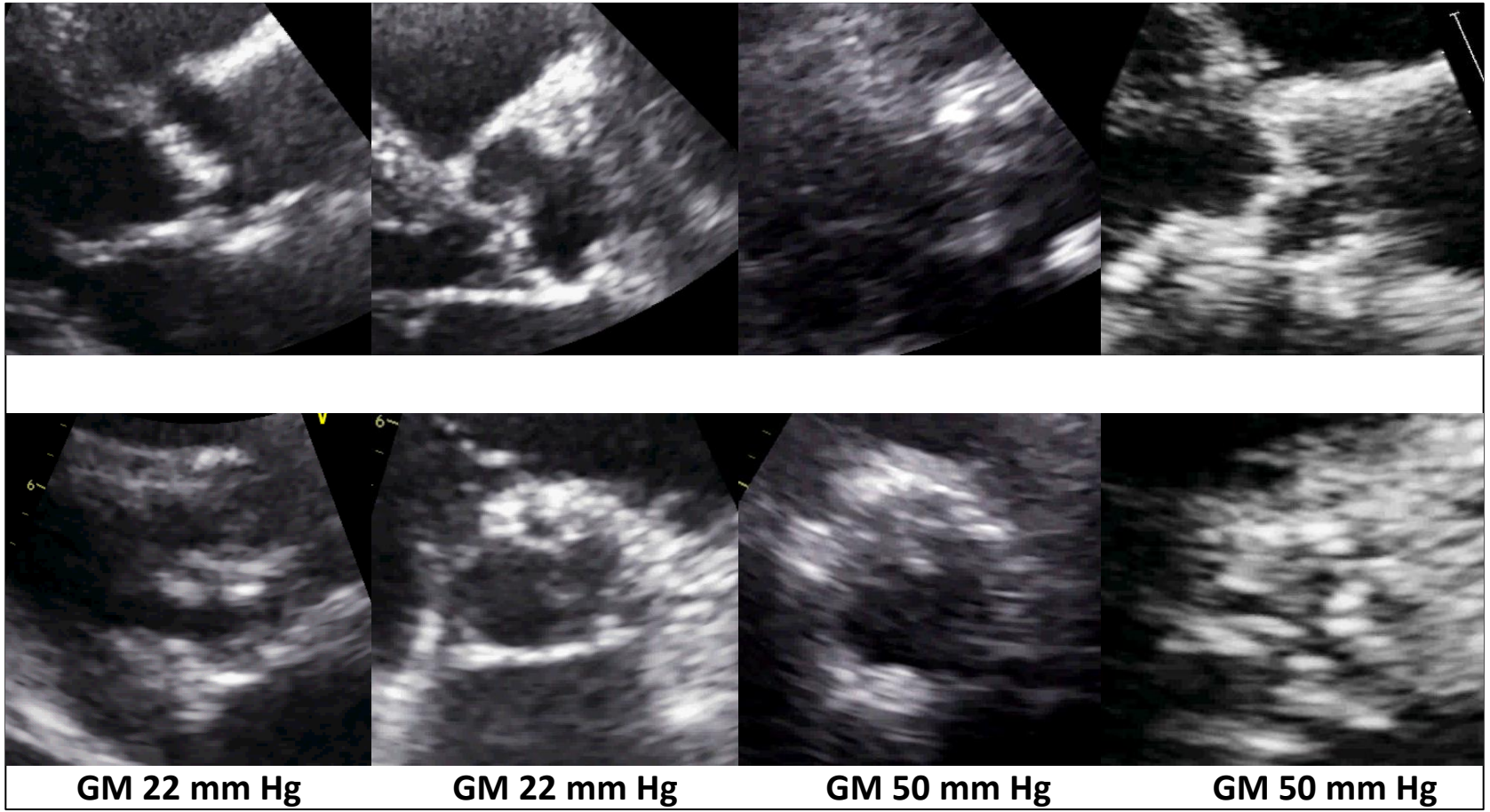
Figure 1. Diagrams of different grades of aortic valve calcification. Grade 1 *(1)*, no calcification; grade 2 *(2)*, mild calcification (small isolated spots of calcification); grade 3 *(3)*, moderate calcification (multiple larger spots of calcification); and grade 4 *(4)*, heavy calcification (extensive calcification of all aortic valve leaflets).



Quelle valve est la plus calcifiée?

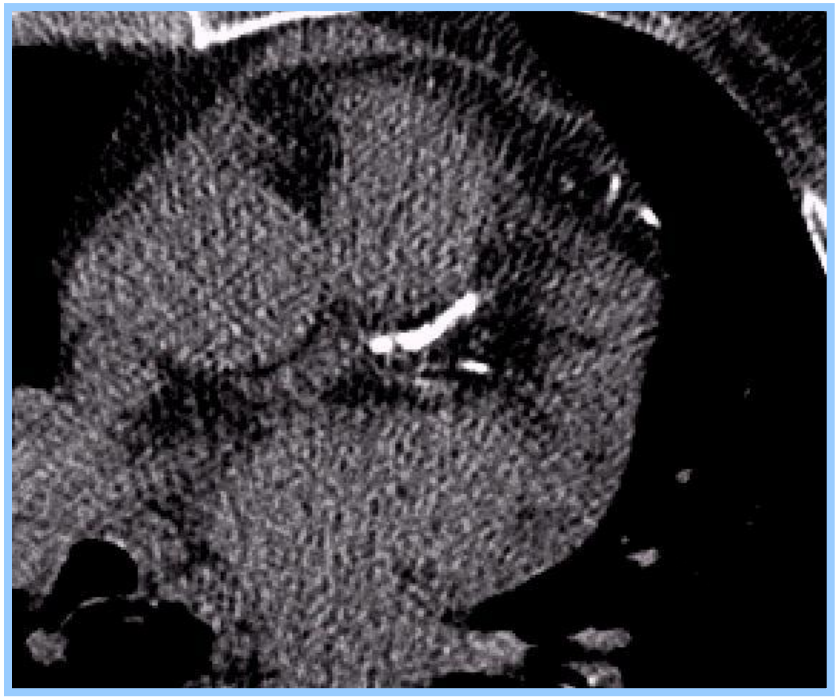


Quelle valve est la plus calcifiée?



CT = évaluation objective et quantitative

Calcifications aortiques

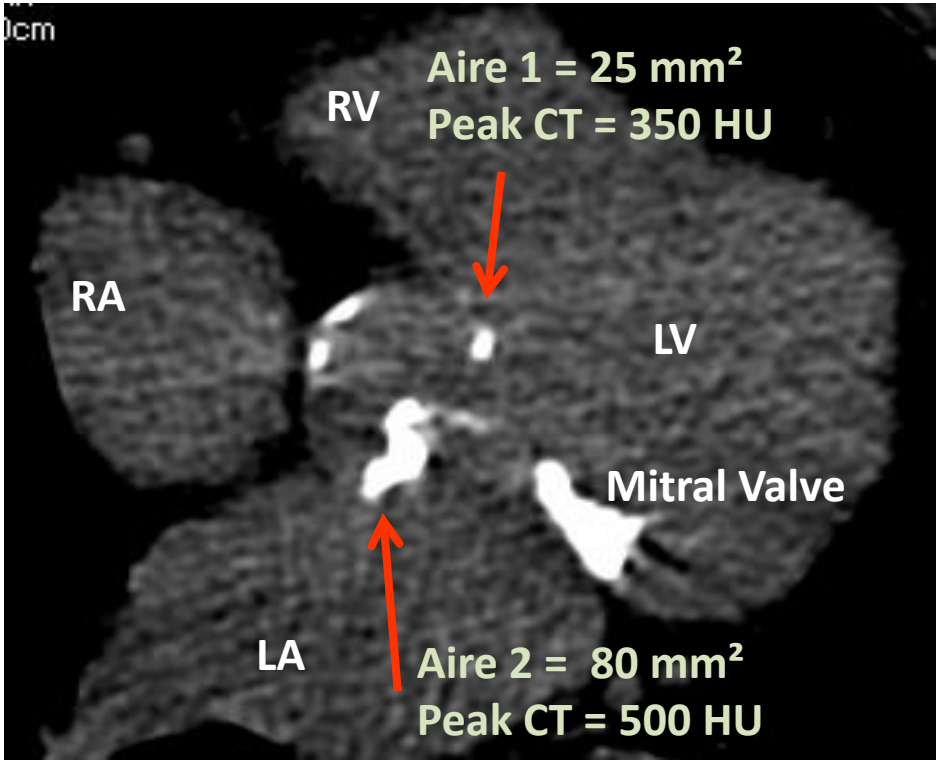


Calcifications coronaires

Mesure du score calcique

- Semi-automatique
- 4 pixels adjacents avec seuil de densité de 130 HU
- L'opérateur attribue la calcification à la valve

Score d'Agatston



Peak density score

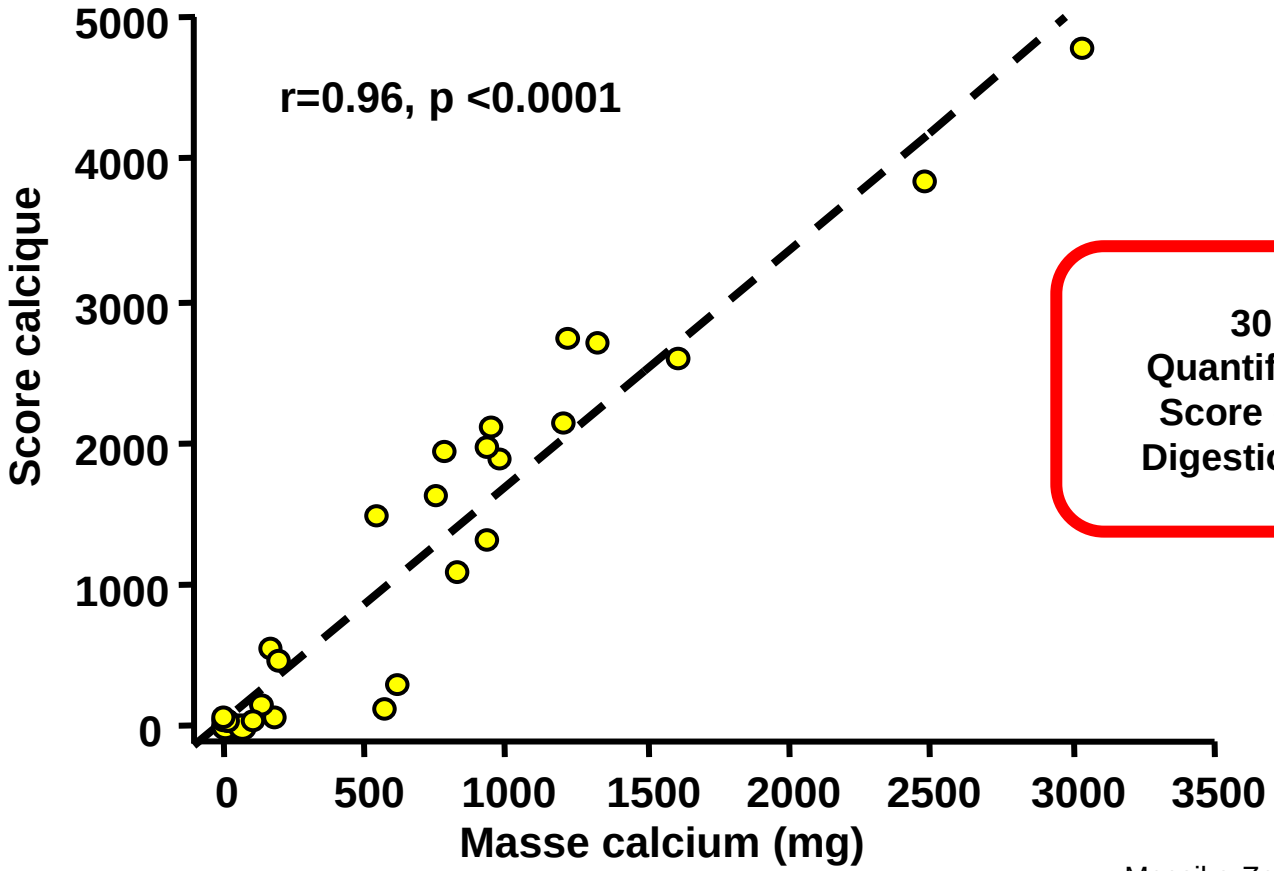
HU	X Factor
130-199	1
200-299	2
300-399	3
> 400	4

Aire 1. Score = 25 * 3 = 75

Aire 2. Score = 80 * 4 = 320

- **Pour chaque region d'intérêt, score = density score * aire**
- **Score total: somme du score de chaques regions sur toutes les coupes**

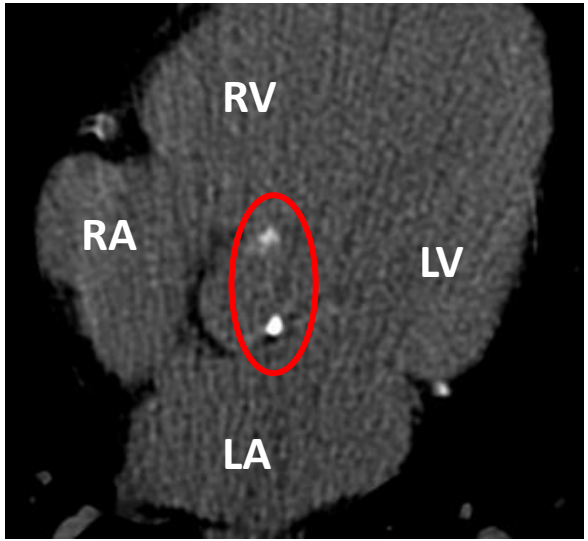
Validation du score calcique



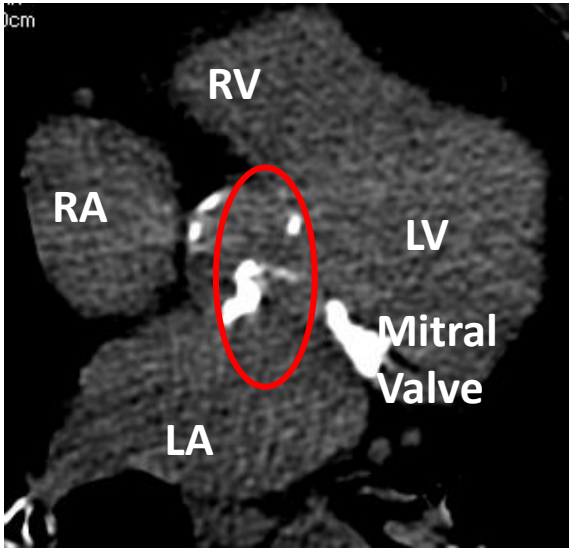
30 valves
Quantification AVC
Score d'Agatston
Digestion tissulaire

Messika-Zeitoun Circulation 2004

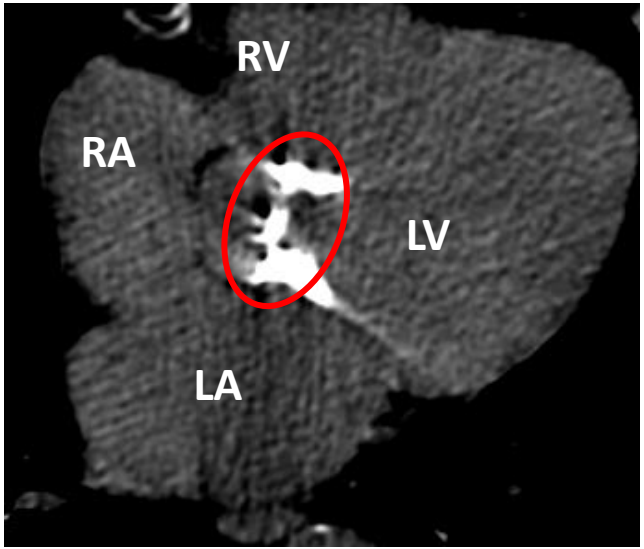
Différents degrés de calcification



AVC. Score = 200 AU



AVC. score = 800 AU

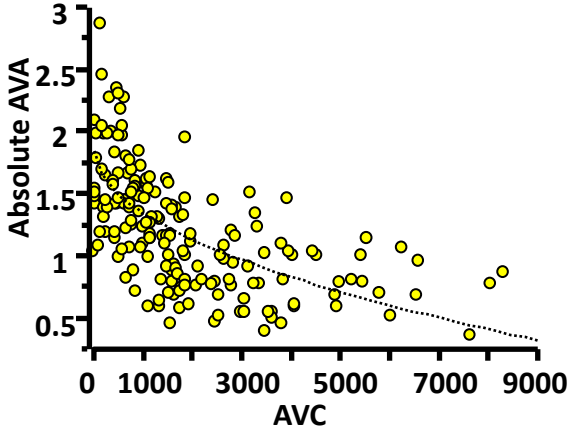


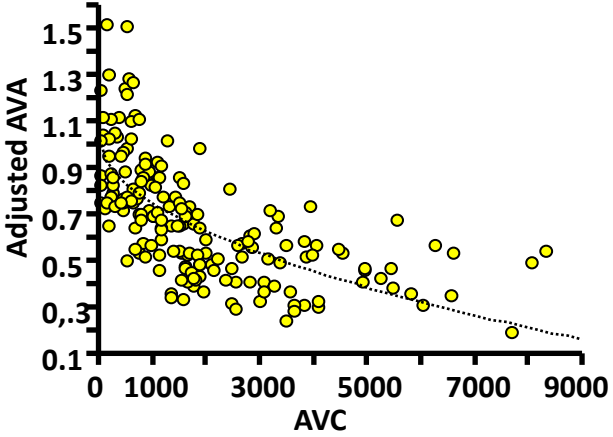
AVC. Score = 2000 AU

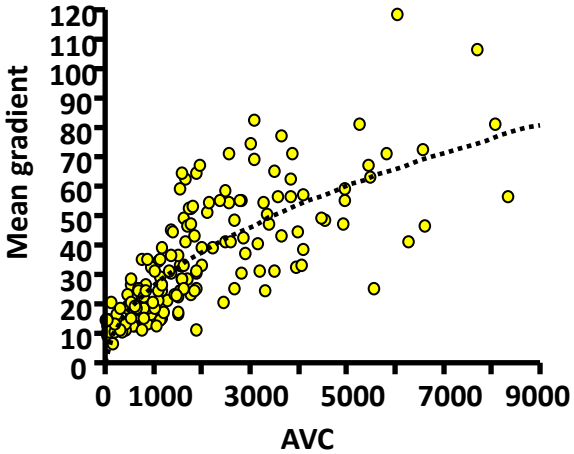
Limites

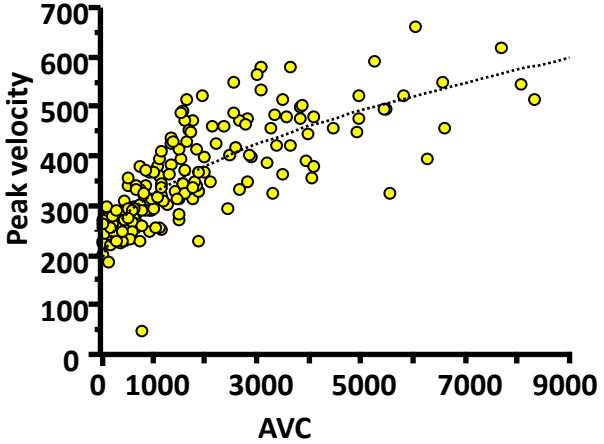
- Pace maker
- Calcifications annulaires mitrales
- Calcification coronaires ostiales
- Calcification pariétale de l’aorte
- Epaisseur de coupe
- RAC «non dégénératifs»

Score calcique et sévérité hémodynamique







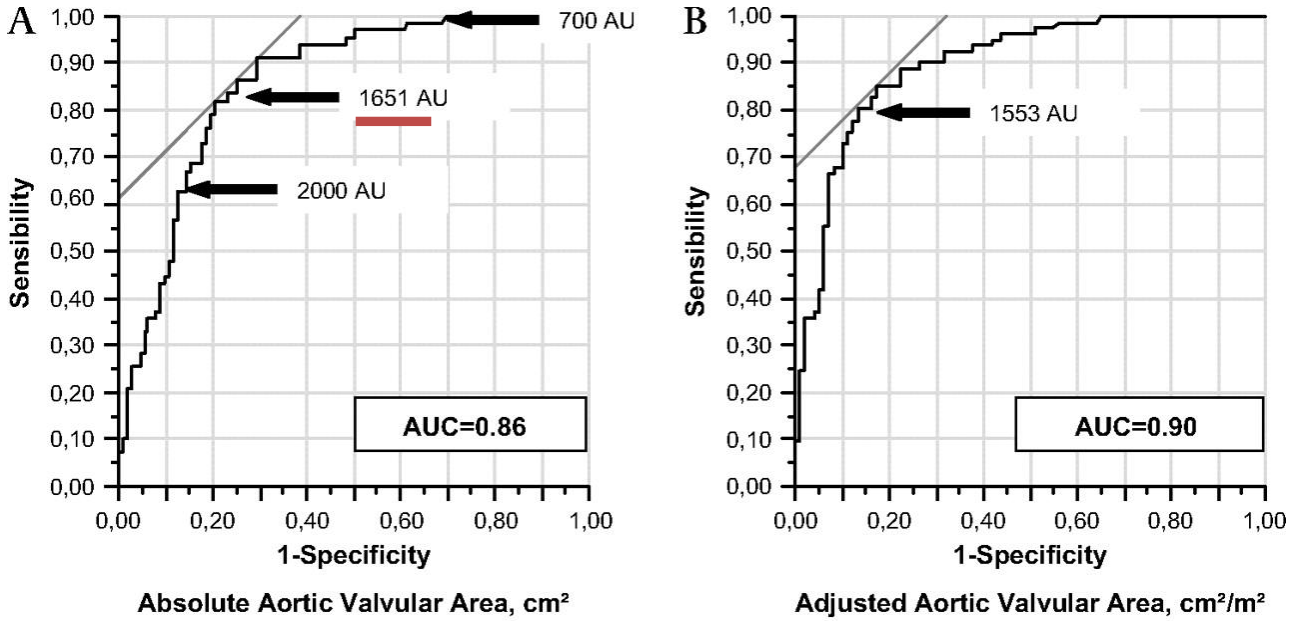


179 patients, MPG >10 mmHg
FEVG > 40%: evaluation set
AVC and AVA: r=-0.63, p<0.0001

Cueff C, Heart 2011

Score calcique et sévérité hémodynamique

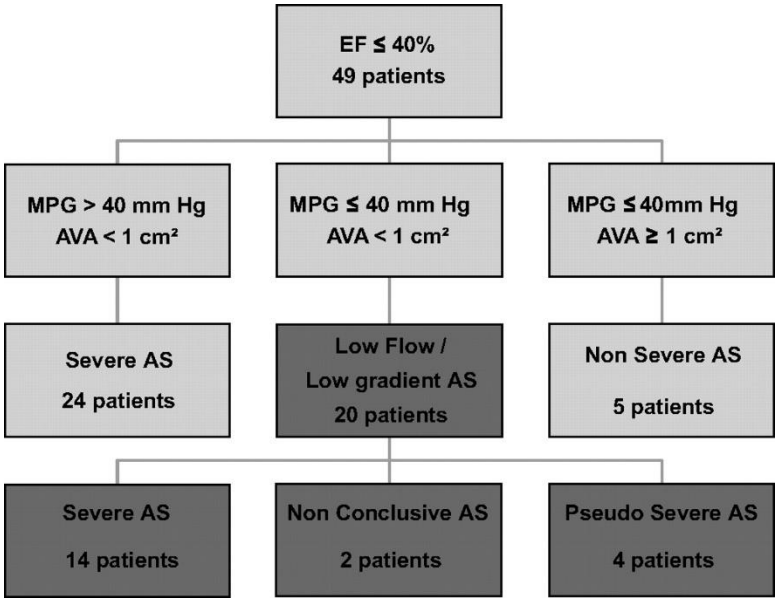
179 patients
FEVG > 40%: evaluation set
ROC curve AVA < 1cm2 et 0.6cm2/m2



Cueff C, Heart 2011

Score calcique et Low flow / Low gradient

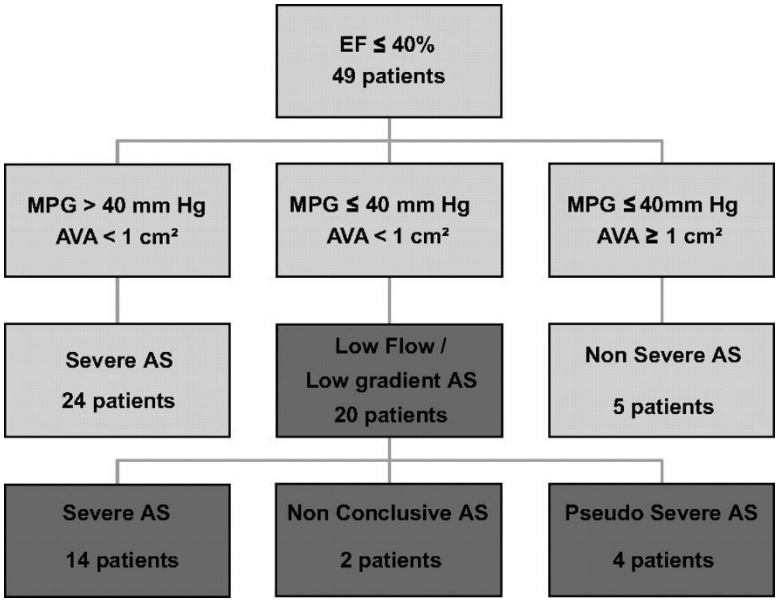
49 patients with FEVG < 40%: testing set



Cueff C, Heart 2011

Score calcique et Low flow / Low gradient

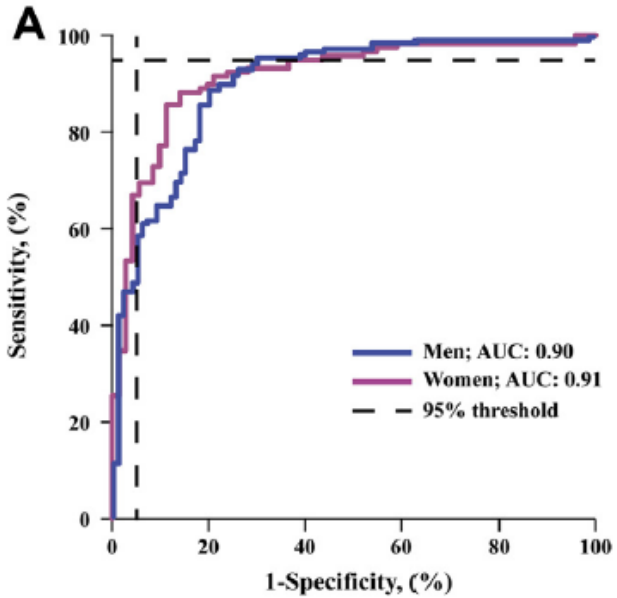
49 patients with FEVG < 40%: testing set



Low gradient/low flow AS (N=18)	Severe AS	Non-severe AS	
CS ≥1651	13	1	Positive-predictive value 93%
CS <1651	1	3	Negative-predictive value 75%
	Sensitivity 93%	Specificity 75%	

Cueff C, Heart 2011

Seuil de sévérité du score calcique



646 patients, multicentrique
MPG ≥25 mmHg, Vmax ≥2.5 m/s ou AVA ≤1.5 cm2
FEVG normale
MPG déterminé par le score calcique (p<0.0001)

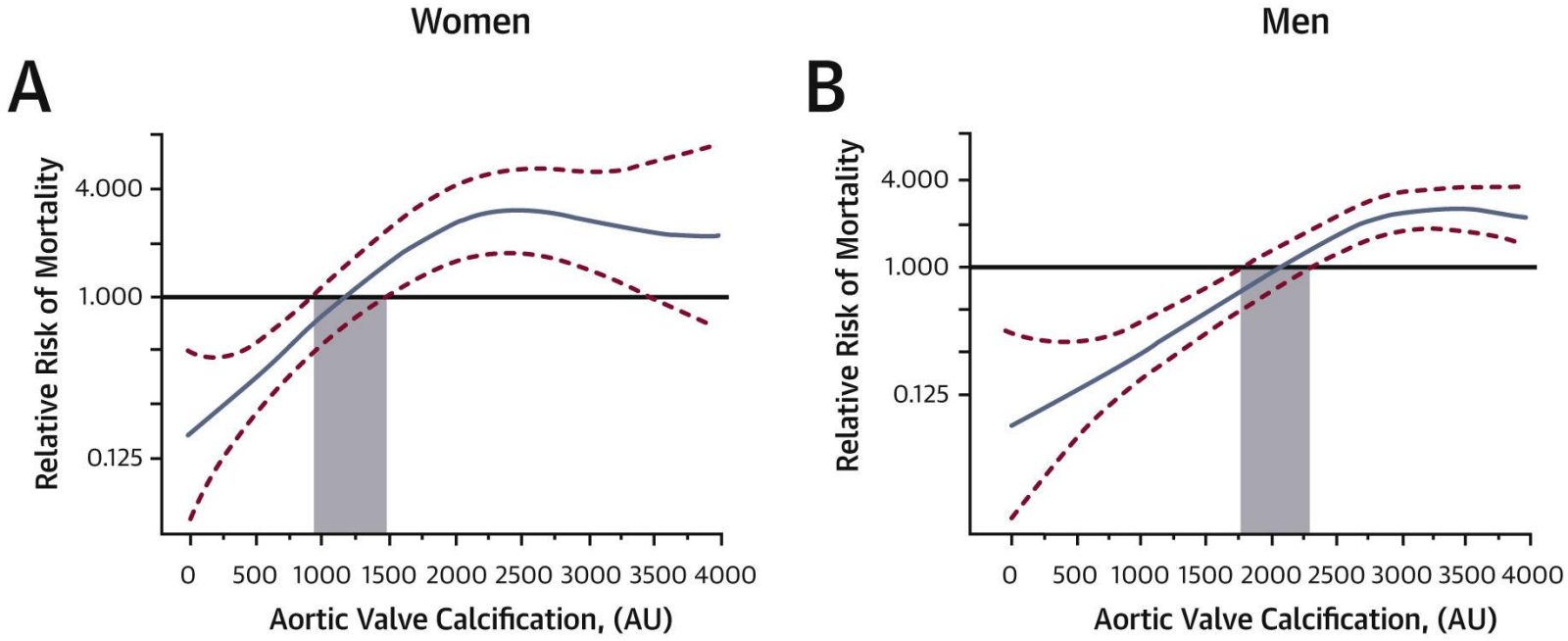
Table 4 Accuracy of AVC, AVCi, and AVCd to Identify Severe AS

Sex	AUC	Threshold	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
AVC						
Women	0.91					
	Specific threshold	1,681*	69	95	95	65
	Best threshold	1,274*	86	89	93	79
	Sensitive threshold	791*	95	63	81	88
Men	0.90					
	Specific threshold	3,381*	59	95	95	59
	Best threshold	2,065*	89	80	88	82
	Sensitive threshold	1,661*	95	70	84	90

451 patients avec SVi >35 ml/m2 et classification concordante (modérée ou sévère)

Clavel MA, JACC 2013

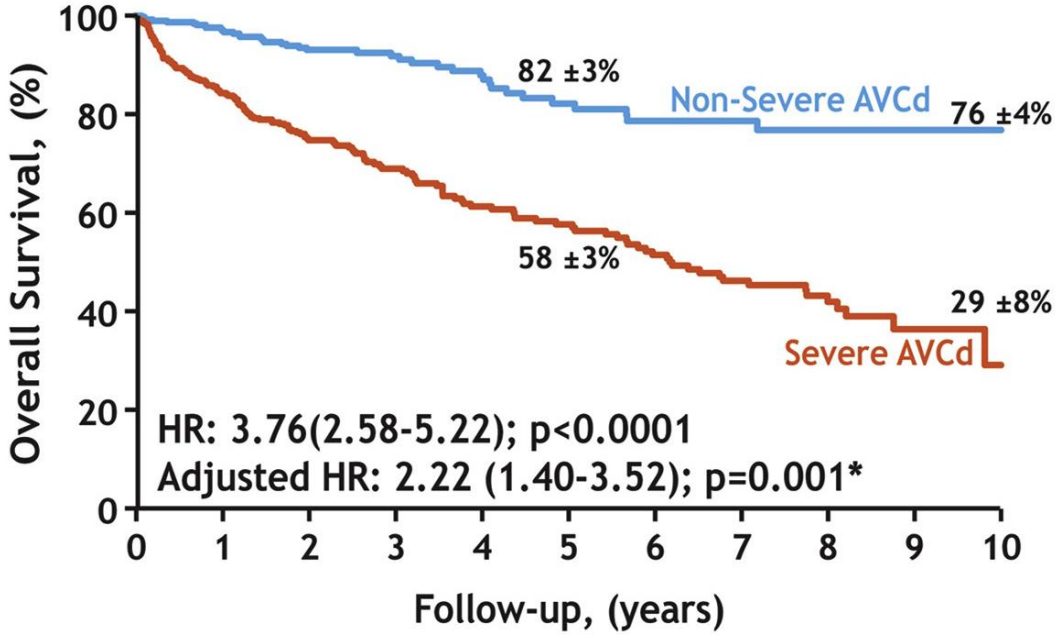
Rôle pronostique du score calcique



794 patients, multicentrique
MPG ≥15 mmHg, Vmax ≥2 m/s ou AVA ≤2 cm2
FEVG normale
Endpoint: mortalité sous traitement médical
Suivi 3.1 ± 2.6 years: 194 décès, 440 interventions

Clavel MA, JACC 2014

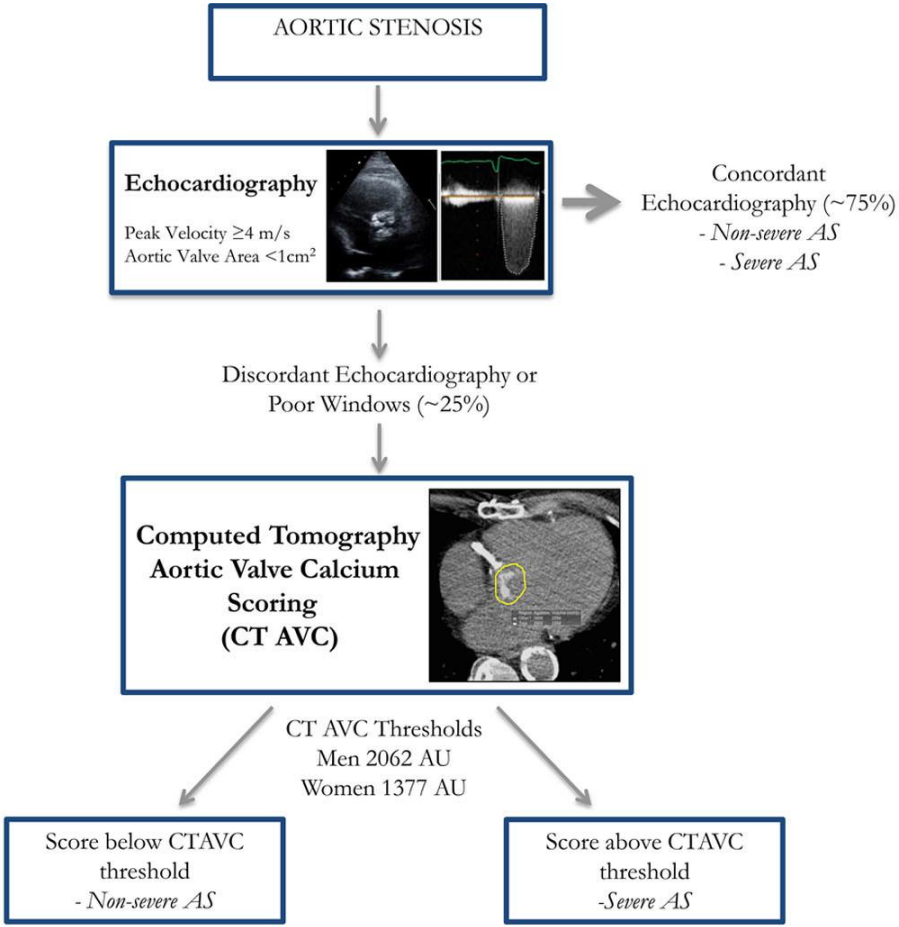
Rôle pronostique du score calcique



AVC ≥1,274 AU pour les femmes et ≥2,065 AU pour les hommes

Clavel MA, JACC 2014

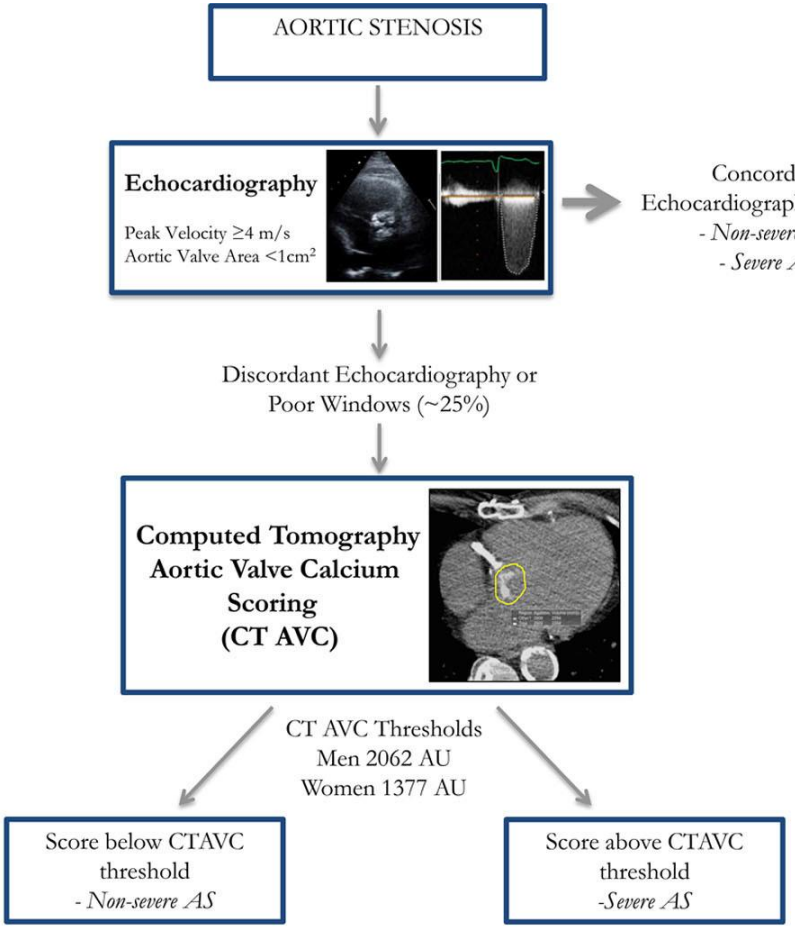
Rôle pronostique du score calcique



918 patients, multicentrique
708 concordants
Hommes: 2062 AU, Femmes: 1377 AU

Pawade T, Circ cardiovasc imaging 2018

Rôle pronostique du score calcique



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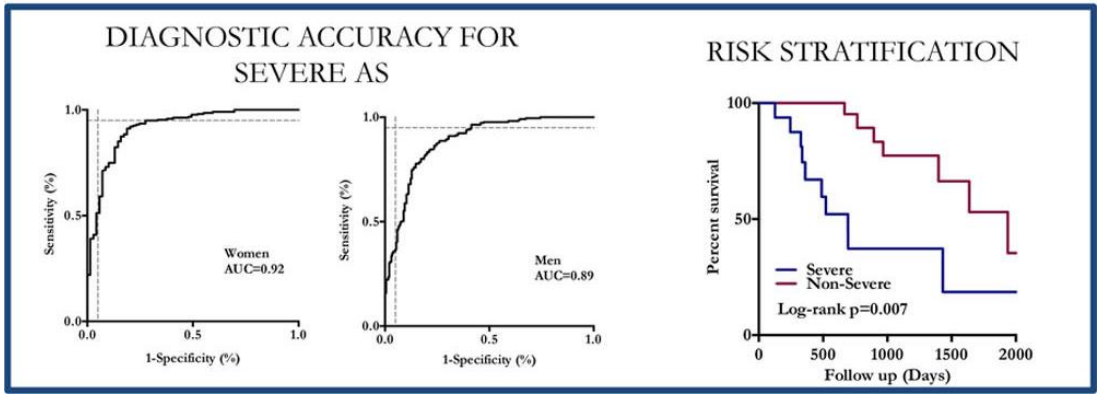
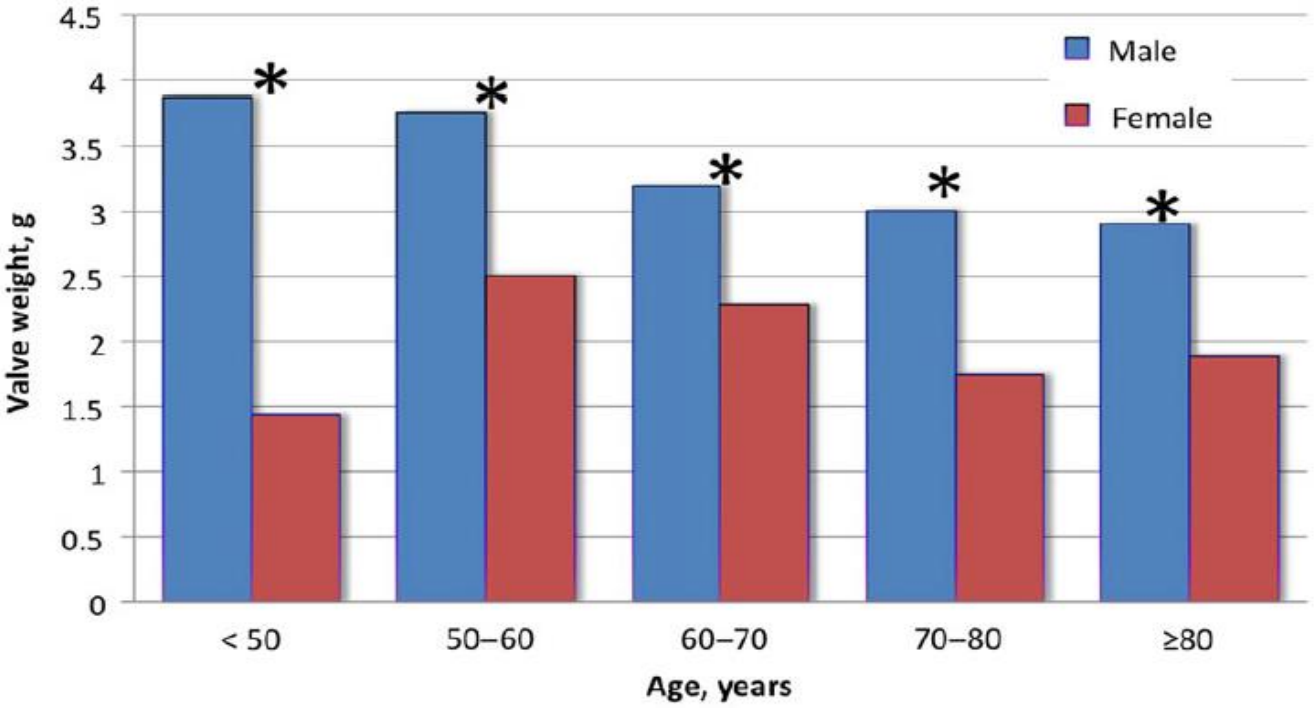


Pawade T, Circ cardiovasc imaging 2018

Différence liée au sexe



Thaden JJ, EHJ 2015

Prediction of paravalvular leakage after transcatheter aortic valve implantation

Di Martino LFM, Int J Cardiovasc Imaging 2015

164 patients avec RAC sévère traités par TAVI (Corevalve)
Prédicteurs de fuite au moins modérée

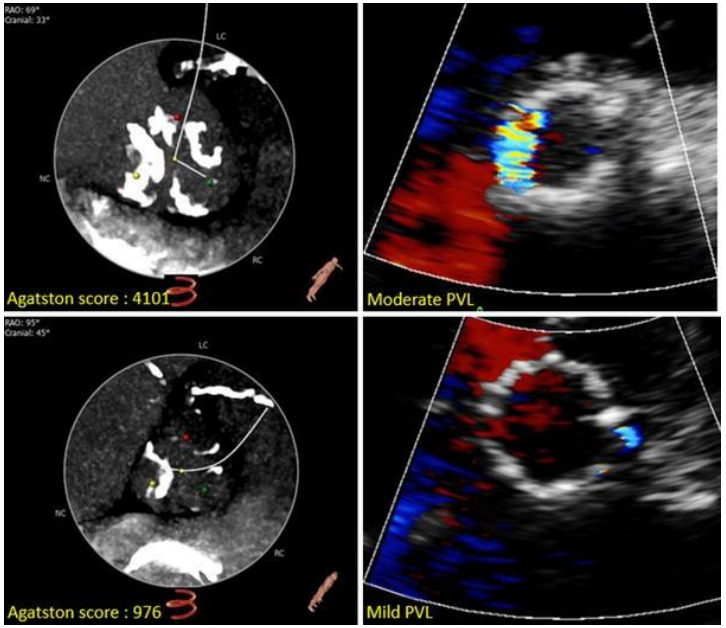
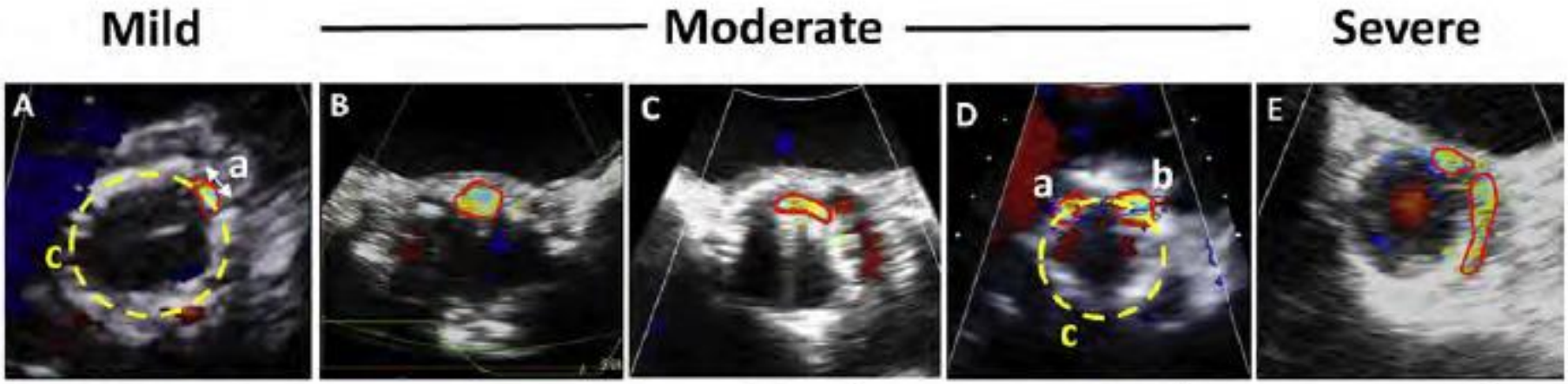


Table 5 Correlations between predictors for aortic paravalvular leakage and actual paravalvular leakage as assessed by echocardiography (VARC-2) and angiography (Sellers)

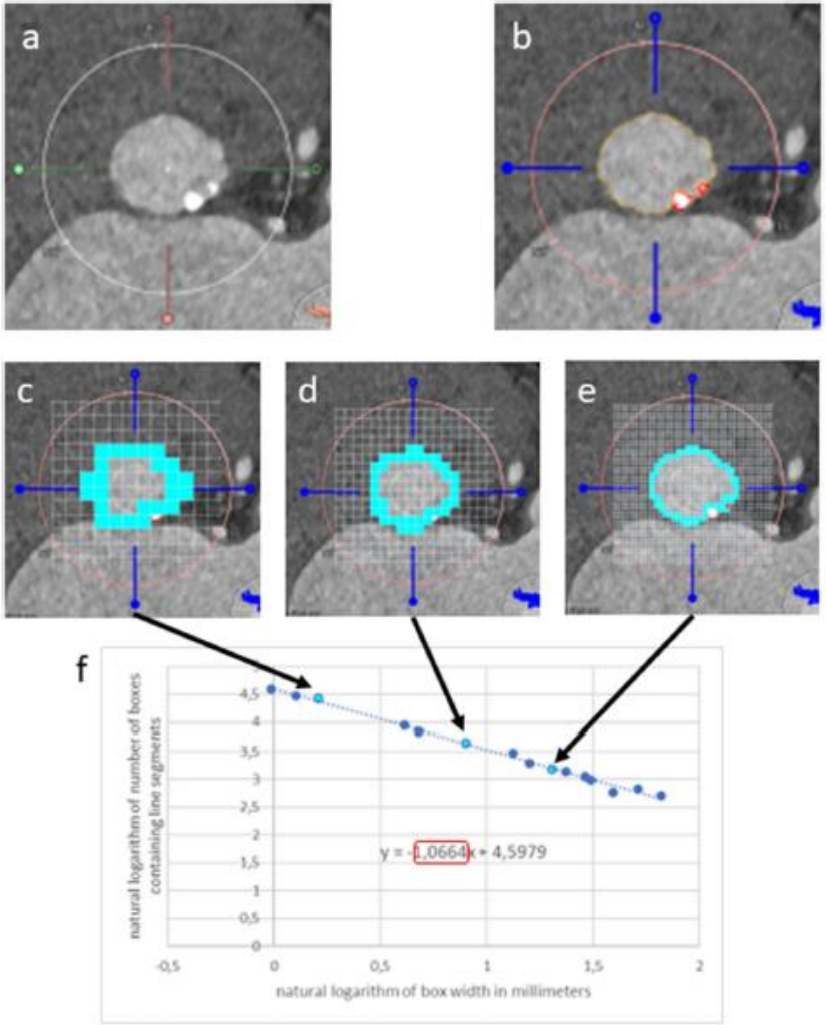
Predictor	VARC-2 score		Angiography score	
	ρ value	*p* value	ρ value	*p* value
Maximal annulus diameter	0.210	0.003	0.178	0.005
Cover index	–0.134	0.043	–0.143	0.019
Eccentricity index	0.030	0.350	0.036	0.303
Agatston score	0.305	<0.001	0.395	<0.001



VC Area	0.1 cm^2	0.2 cm^2	0.2 cm^2	0.26 cm^2	0.7 cm^2
% Circ	8 %	10 %	16 %	18 %	30 %

Fractal dimension of the aortic annulus: a novel predictor of paravalvular leak after transcatheter aortic valve implantation

Stachel G et al, Int J CVI, 2022



122 patients traités par TAVI (Sapiens 3 ou Evolut R)

Fractal dimension of the aortic annulus: a novel predictor of paravalvular leak after transcatheter aortic valve implantation

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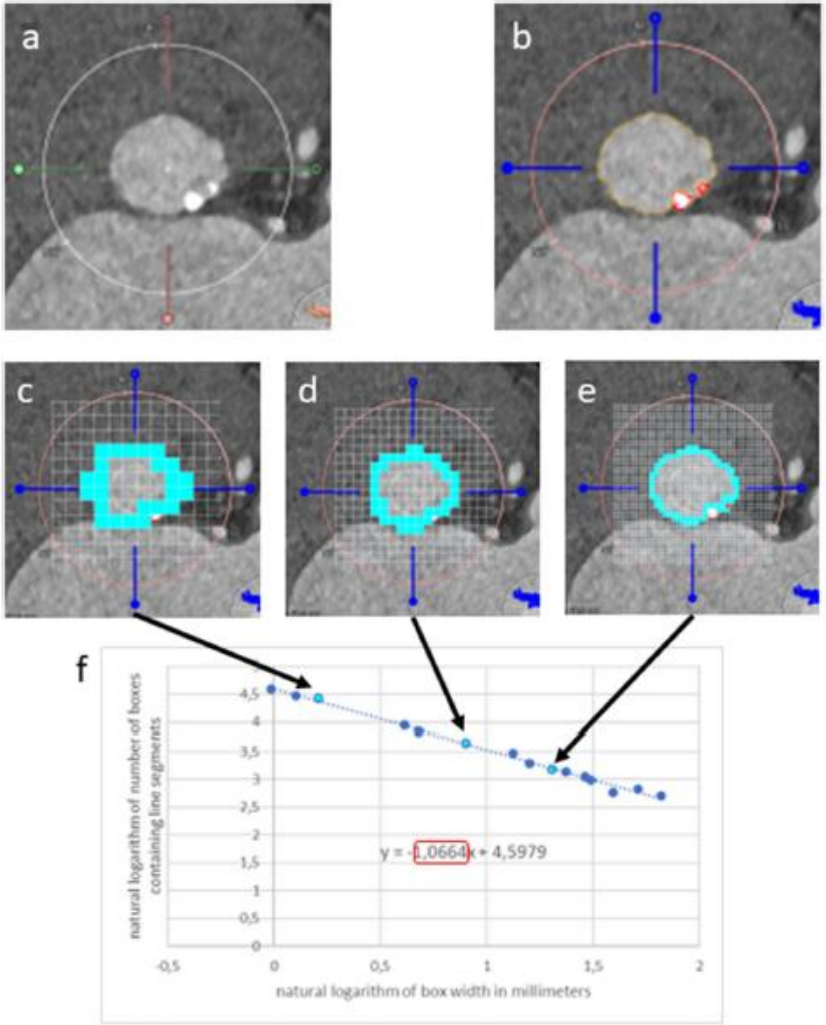
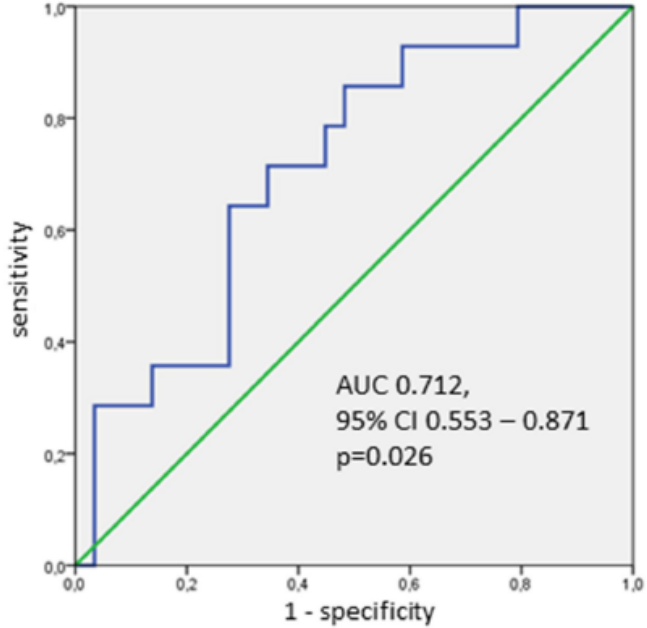
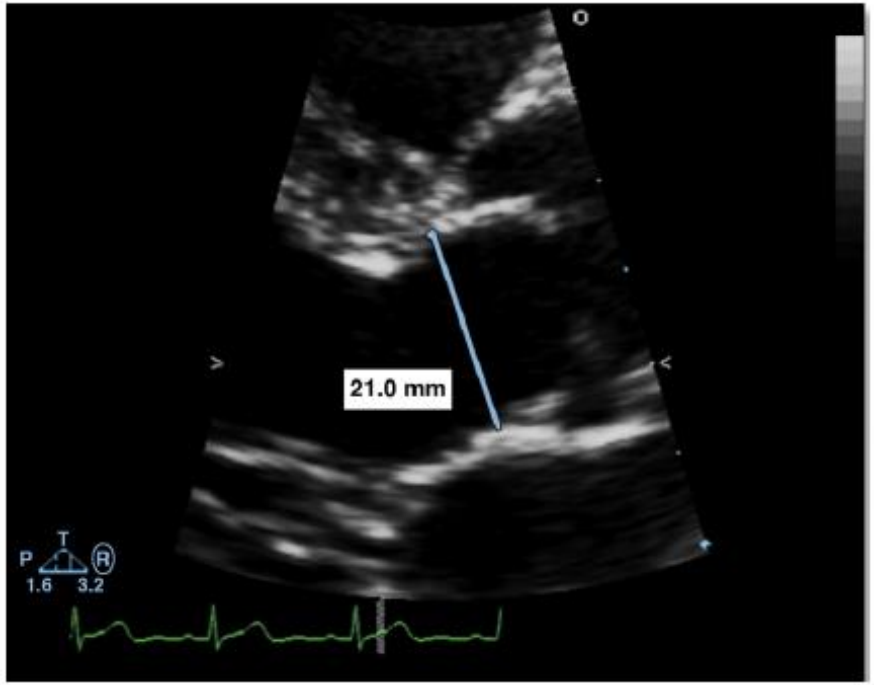


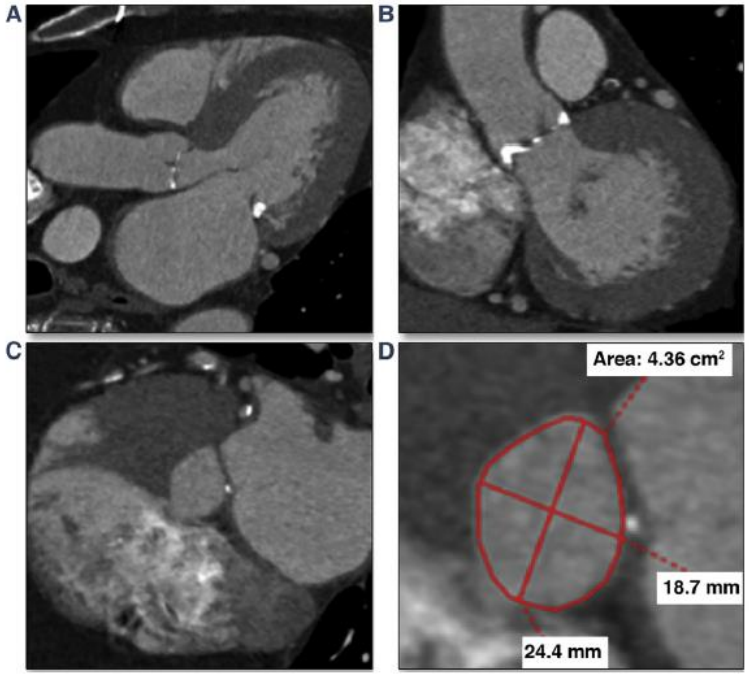


Prediction of mild or more PVR after TAVI treatment by fractal dimension of annulus

Aortic Valve Area Calculation in Aortic Stenosis by CT and Doppler Echocardiography

Clavel MA et al, JACC CVI, 2015





$$AVA_{Echo} = LVOTArea_{Echo} \times \frac{VTI_{LVOT}}{VTI_{Ao}}$$

$$AVA_{CT} = LVOTArea_{CT} \times \frac{VTI_{LVOT}}{VTI_{Ao}}$$

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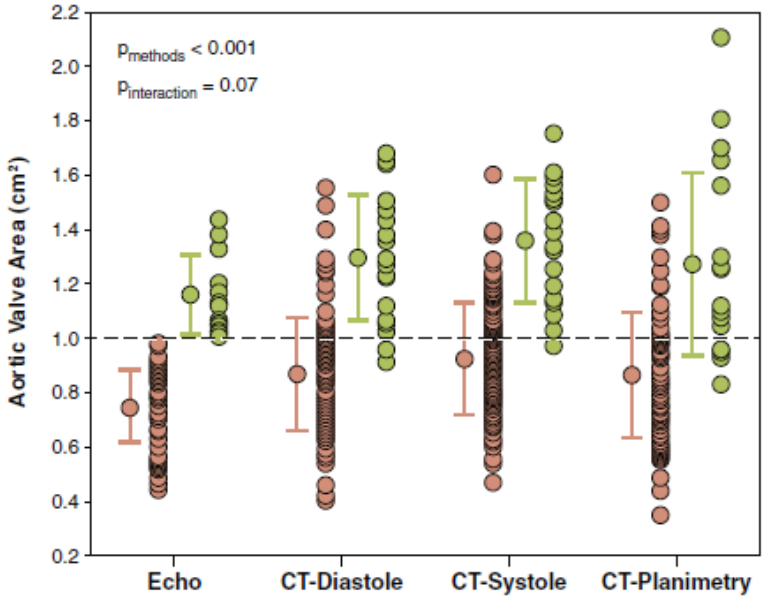

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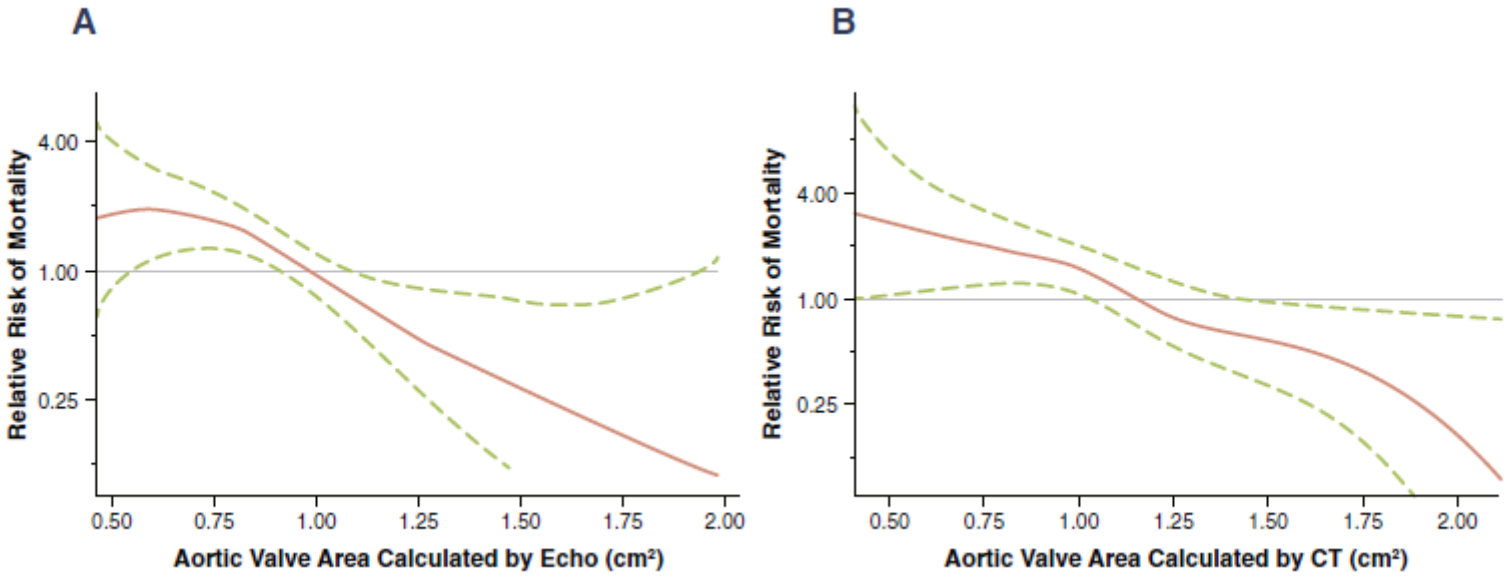
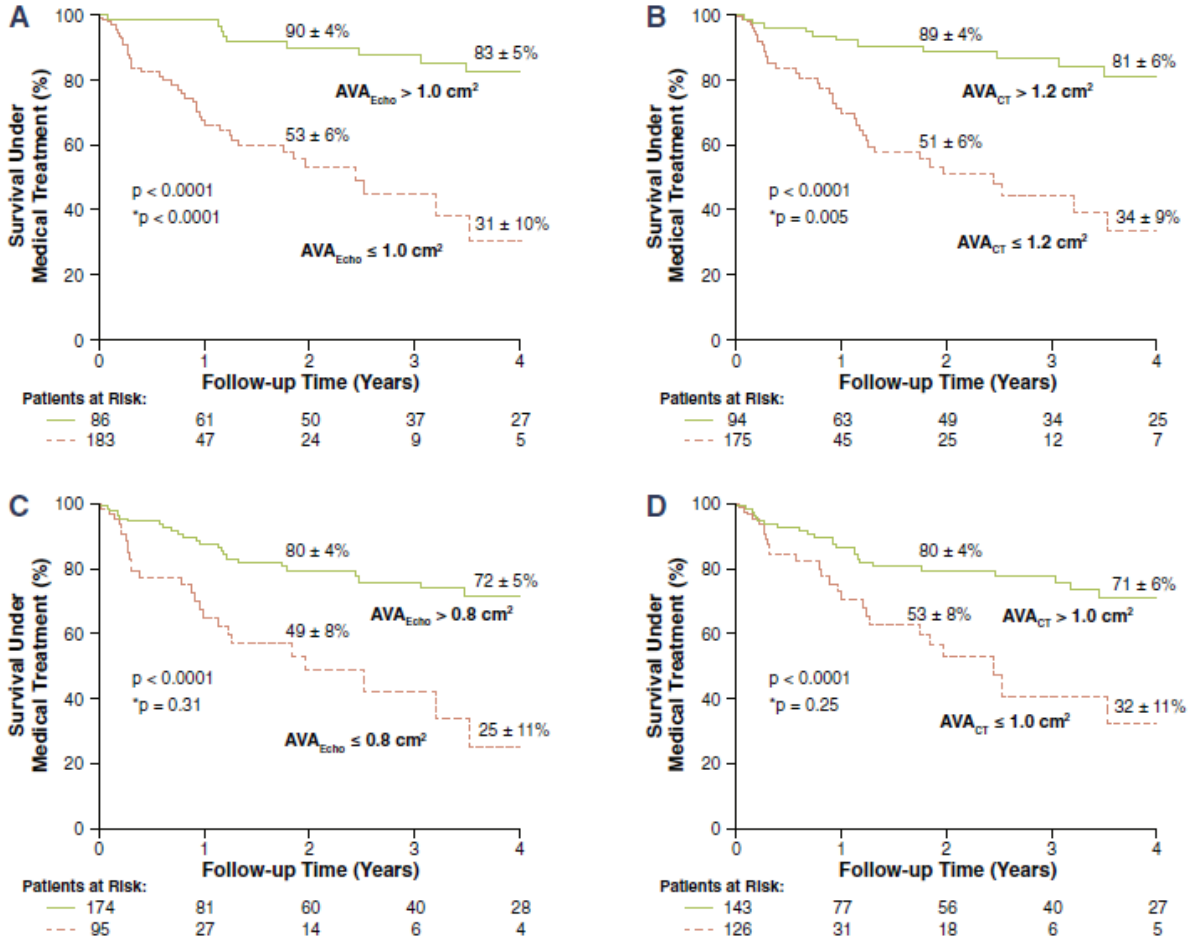


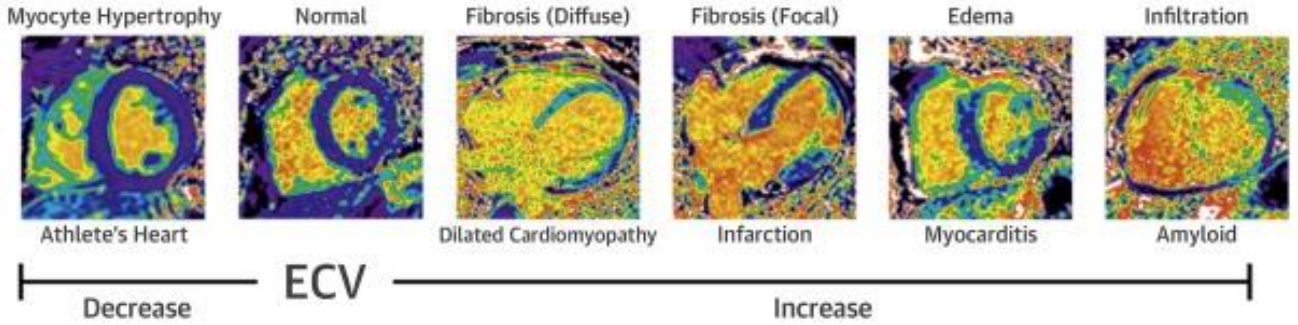
Sévérité AVA 1,2 cm2 en CT

Aortic Valve Area Calculation in Aortic Stenosis by CT and Doppler Echocardiography

Clavel MA et al, JACC CVI, 2015

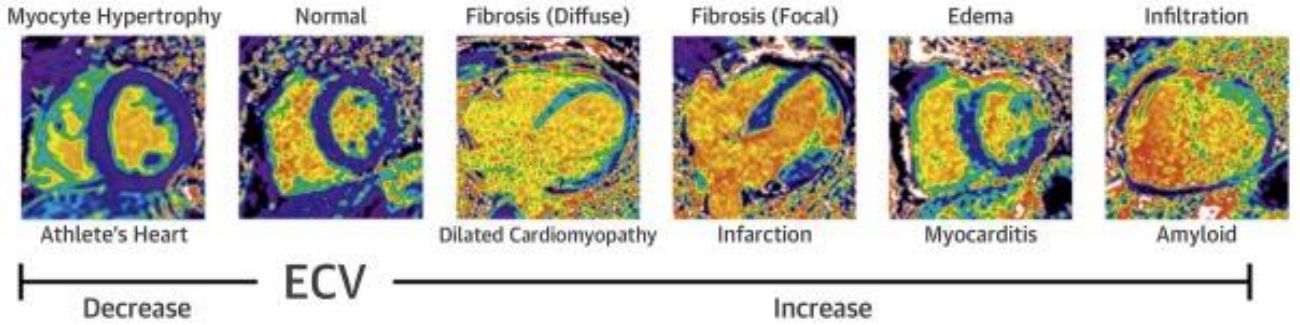


Volume extracellulaire



Robinson, A.A. et al. J Am Coll Cardiol Img. 2019;12(11):2332–44.

Volume extracellulaire



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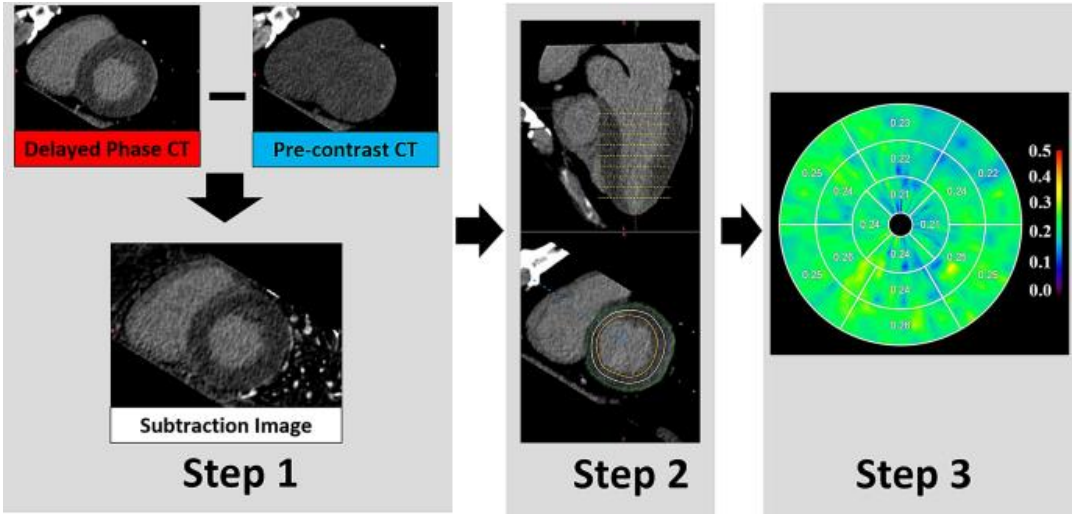
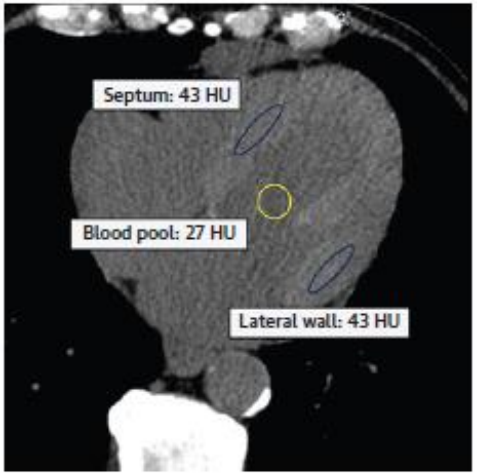


Prognostic Value of Computed Tomography–Derived Extracellular Volume in TAVR Patients With Low-Flow Low-Gradient Aortic Stenosis

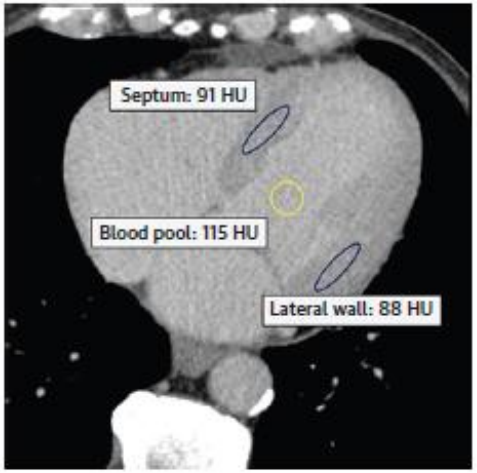
Tamarappoo et al, J Am Coll Cardiol Img, 2020

ECV Quantification From Electrocardiogram-Gated Cardiac Computed Tomography

Pre-contrast



Post-contrast

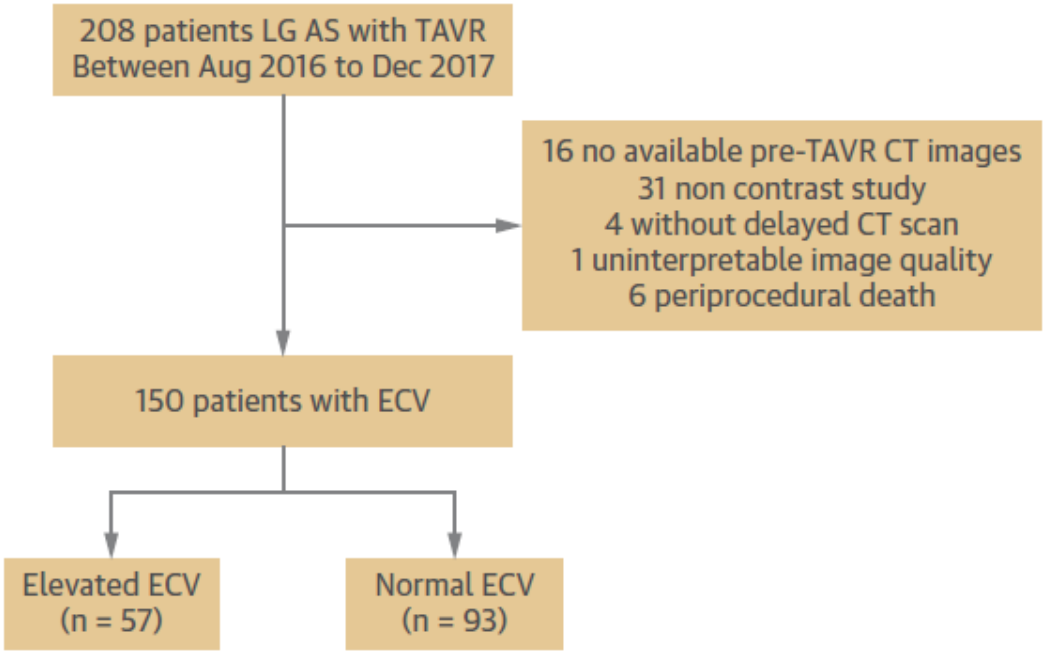


$$ECV_{CT} = (1 - \text{Hematocrit}) \times (\Delta HU_{myocardium} / \Delta HU_{blood\ pool})$$

- $\Delta HU: HU_{post\text{-}contrast} - HU_{pre\text{-}contrast}$

Prognostic Value of Computed Tomography–Derived Extracellular Volume in TAVR Patients With Low-Flow Low-Gradient Aortic Stenosis

Tamarappoo et al, J Am Coll Cardiol Img, 2020



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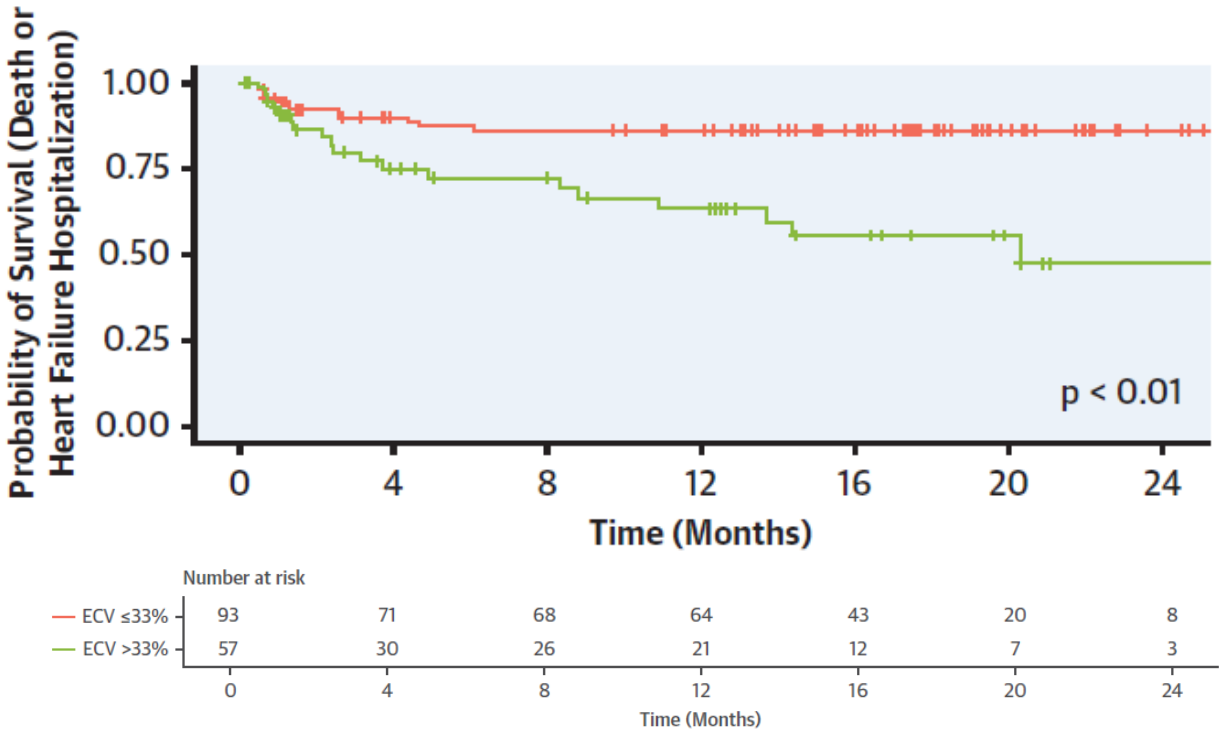
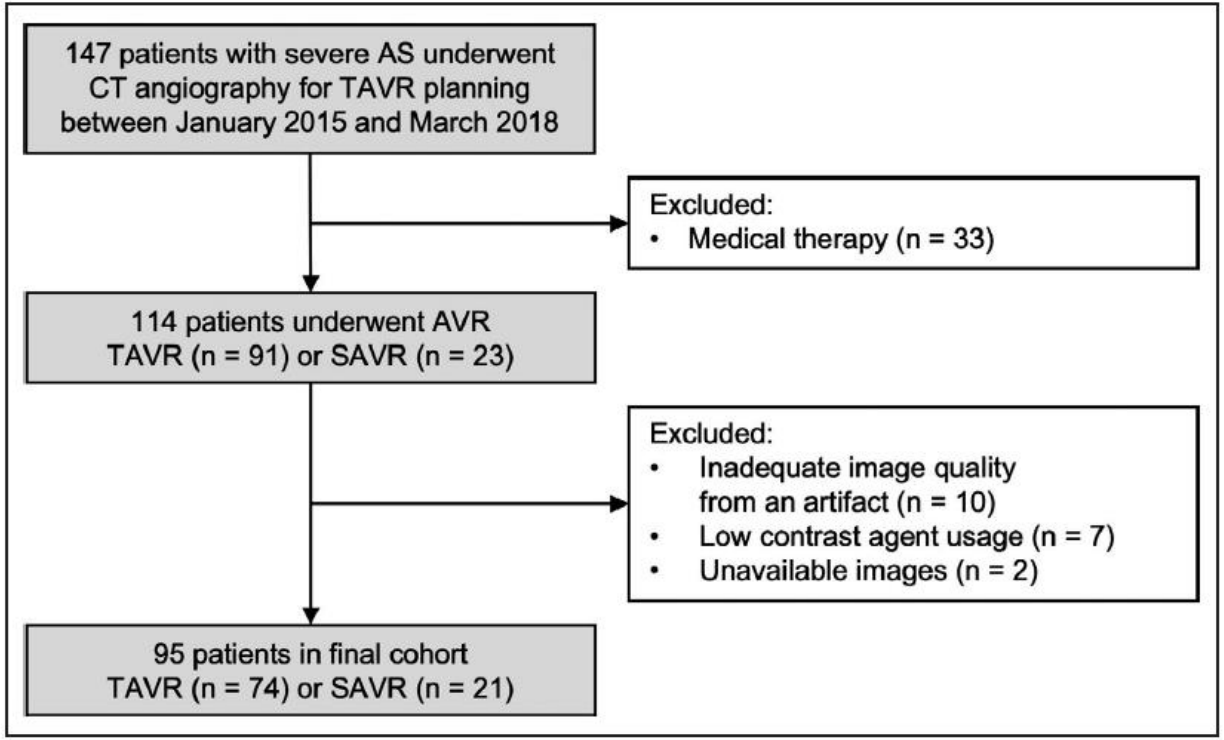
Increased ECV Is Associated With Major Cardiovascular Events



Prognostic Impact of Myocardial Extracellular Volume Fraction Assessment Using Dual-Energy Computed Tomography in Patients Treated With Aortic Valve Replacement for Severe Aortic Stenosis

Suzuki M et al, JAHA, 2021



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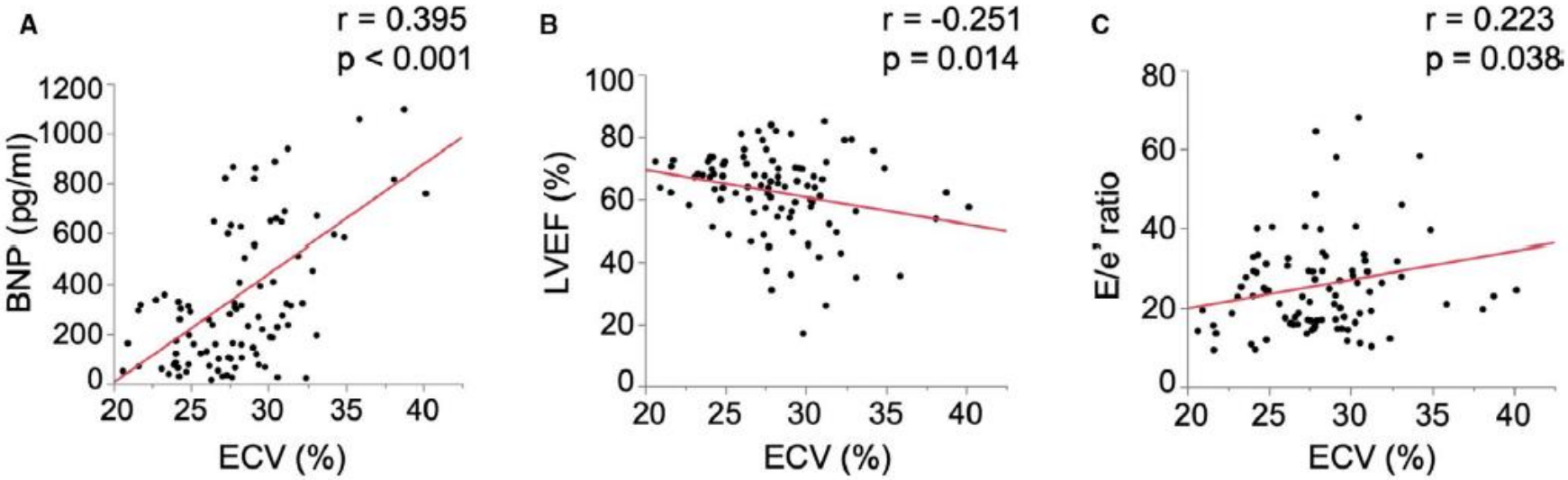

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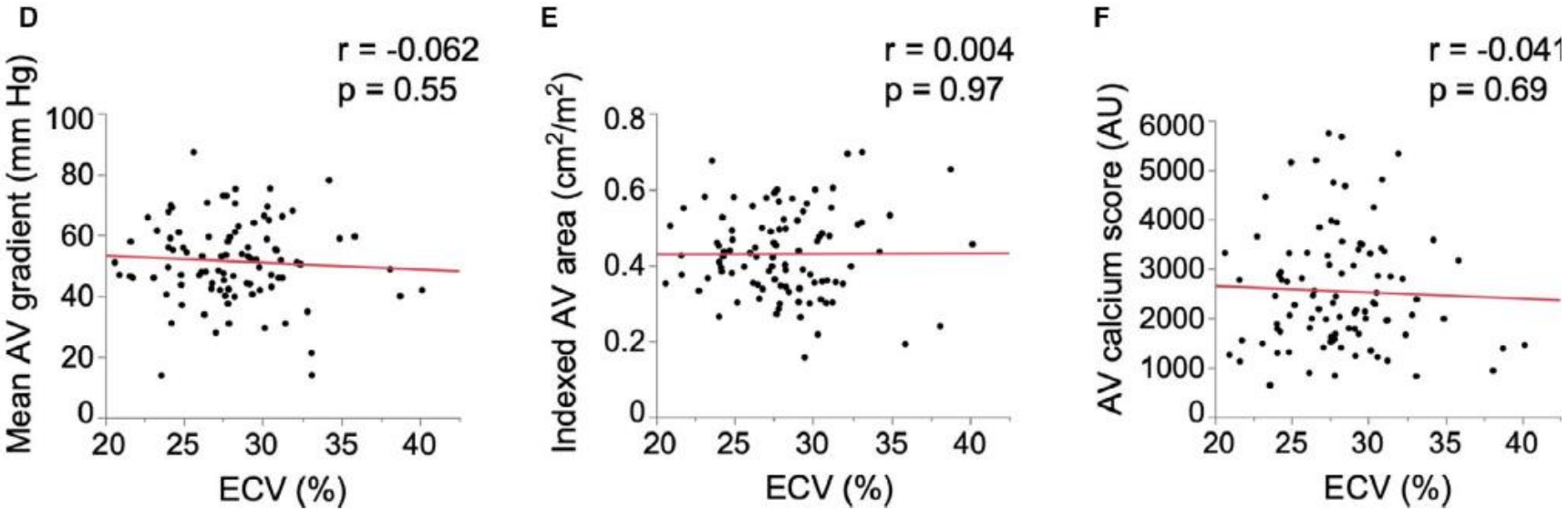

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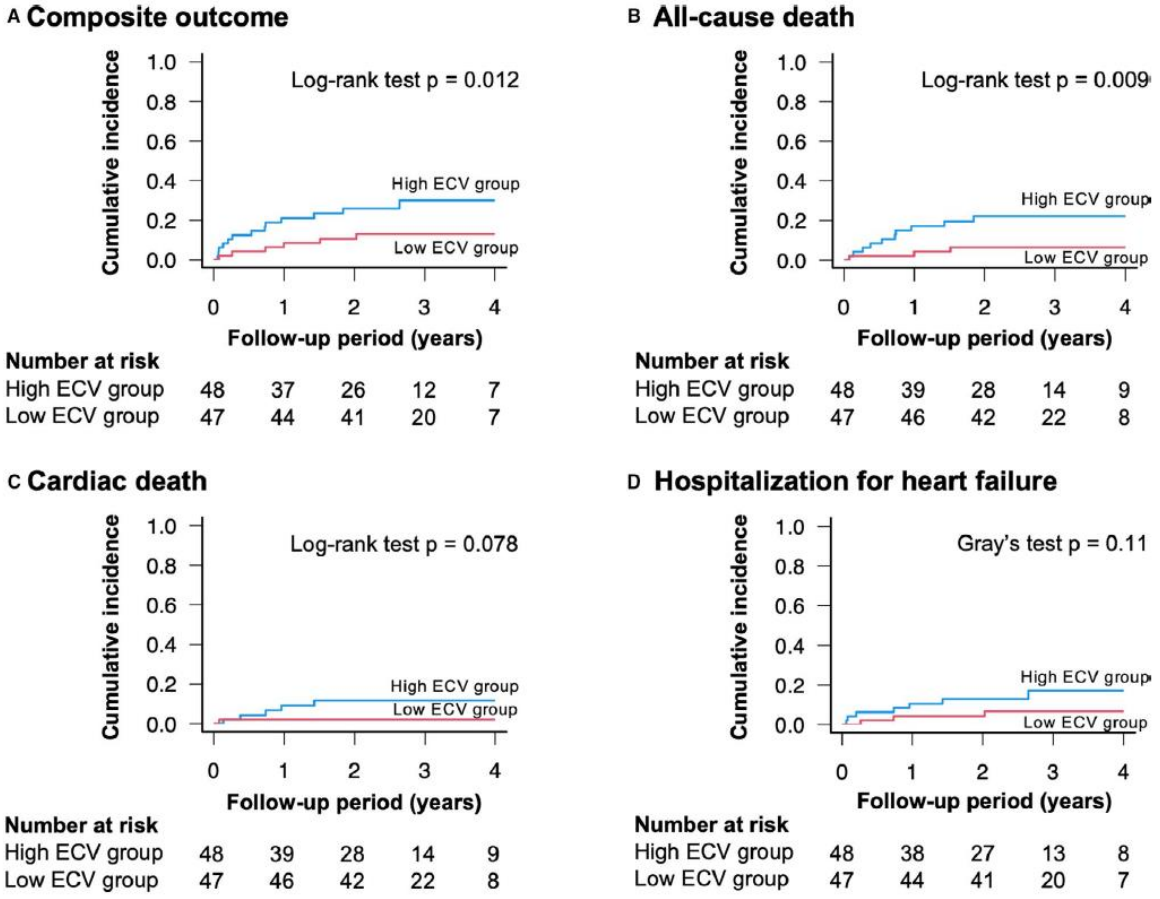
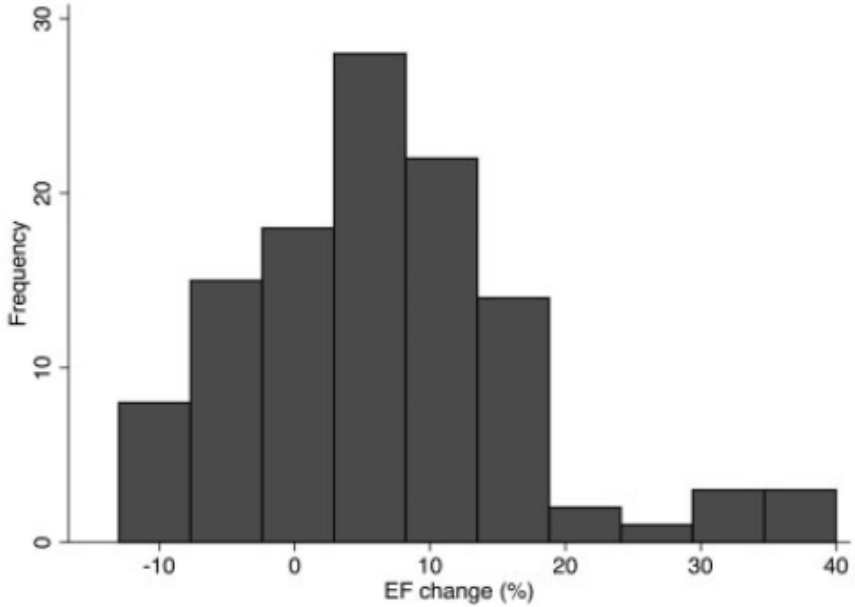
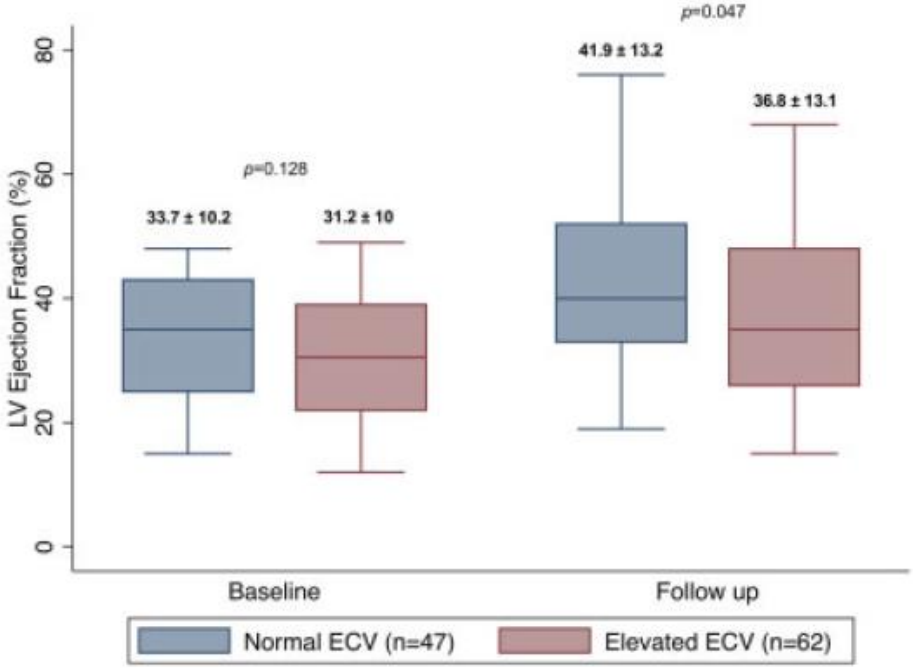


Computed tomography angiography-derived extracellular volume fraction predicts early recovery of left ventricular systolic function after transcatheter aortic valve replacement

Han D et al, EHJ CVI, 2021

109 patients pré TAVI
FEVG < 50%
Amélioration de la FEVG > 10% durant les 6 premiers mois



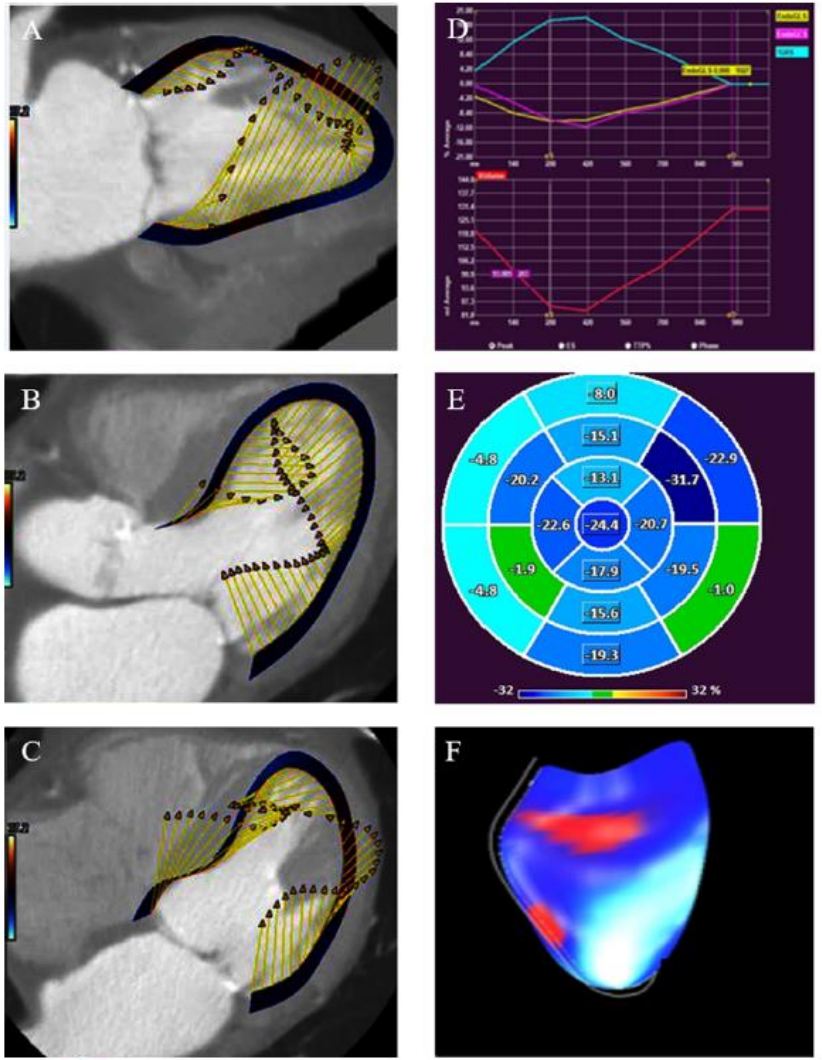


Prognostic Influence of Feature Tracking Multidetector Row Computed Tomography-Derived Left Ventricular Global Longitudinal Strain in Patients with Aortic Stenosis Treated With Transcatheter Aortic Valve Implantation

Gegenava T et al AJC, 2019

Association entre GLS CT et mortalité globale

214 patients traités par TAVI pour RAC serré



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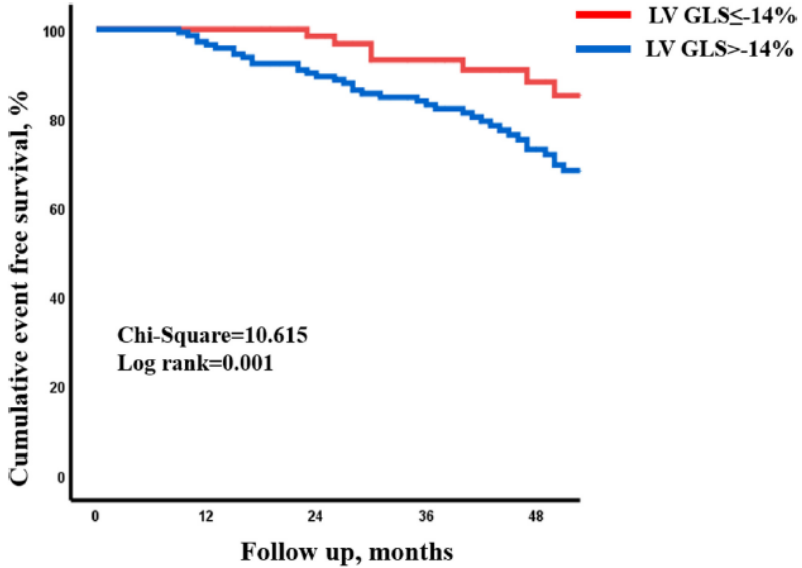
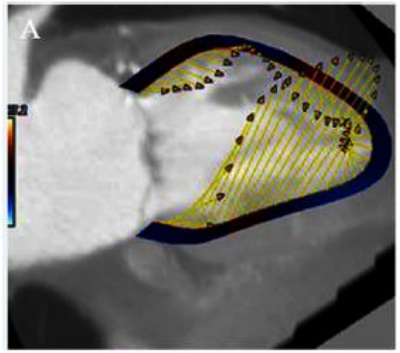
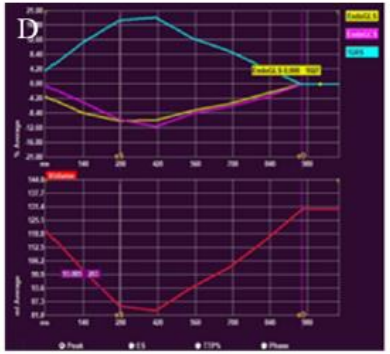
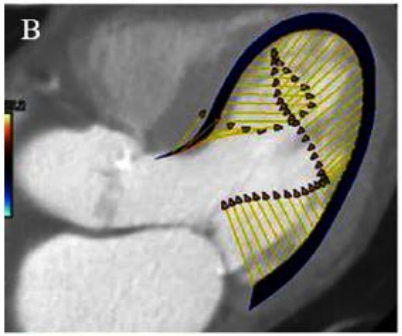
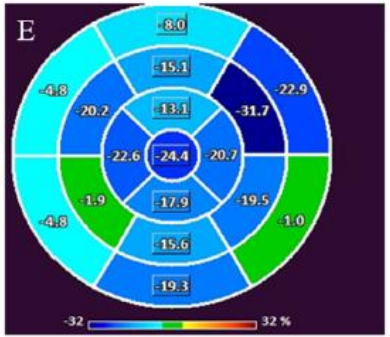


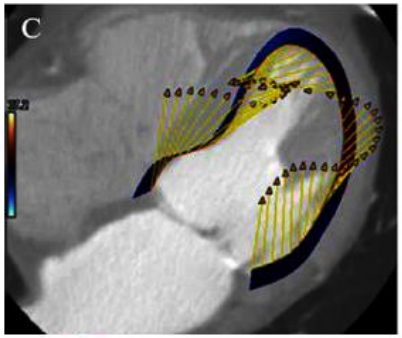
GLS≤-14% (n=72)	70 (98%)	59 (97%)	46 (91%)	29 (85%)
GLS>-14% (n=142)	138 (96%)	121 (89%)	94 (82%)	62 (72%)

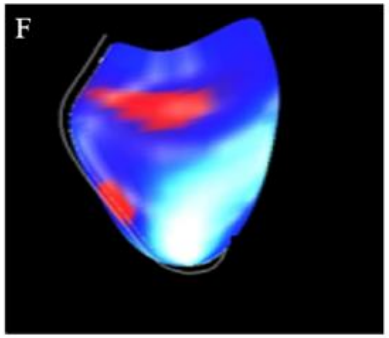






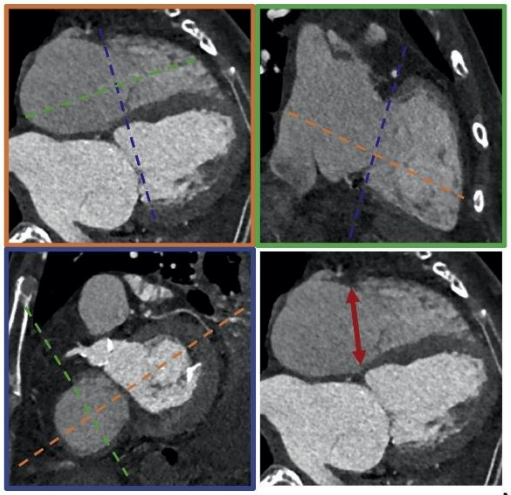




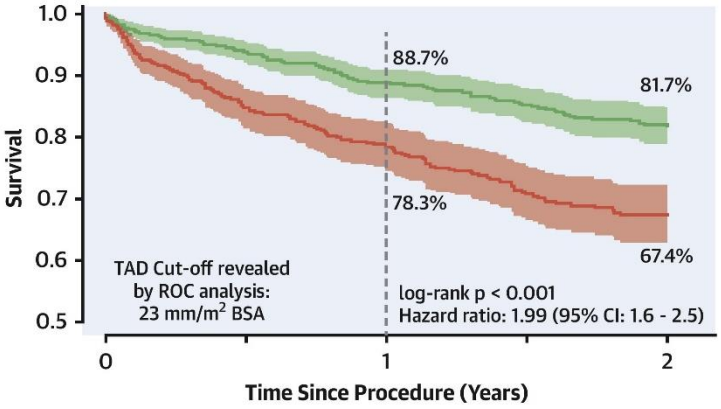


CT-Determined Tricuspid Annular Dilatation Is Associated With Increased 2-Year Mortality in TAVR Patients

Measurement of the Tricuspid Annulus Diameter



Survival Stratified for Tricuspid Annular Dilatation



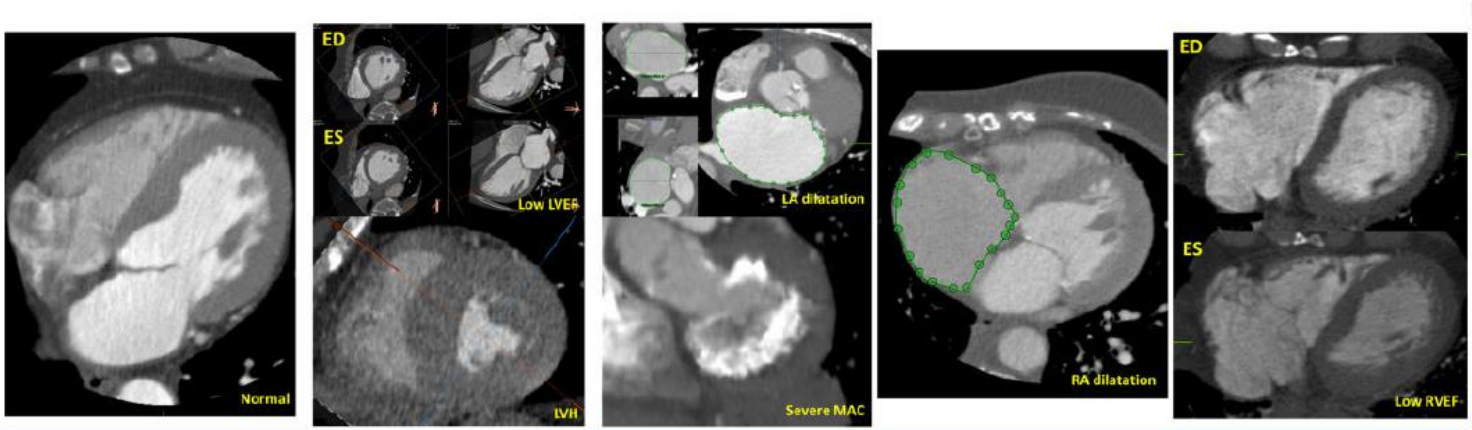
No. at Risk:

No TAD	691	639	603	457	332
TAD	446	374	346	226	170

Deseive, S. et al. J Am Coll Cardiol Intv. 2020;13(21):2497-507.

Prognostic implications of cardiac damage classification based on computed tomography in severe aortic stenosis

Hirasawa K et al, EHJ CVI, 2022



	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
	No cardiac damage	Left ventricular damage	Left atrial or mitral damage	Right atrial damage	Right ventricular damage
MDCT criteria		LV ejection fraction < 50% LV mass index male > 79.2 g/m^2 female > 63.8 g/m^2	Left atrial volume index > 56 ml/m^2 Presence of atrial fibrillation Severe mitral annular calcification	Right atrial volume index > 70 ml/m^2	RV ejection fraction < 35%

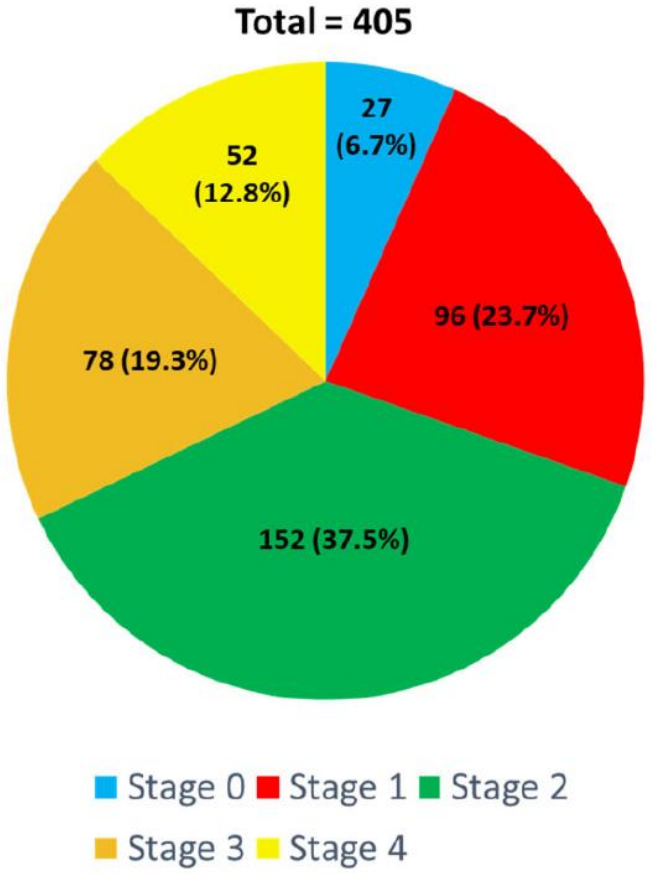
Prognostic implications of cardiac damage classification based on computed tomography in severe aortic stenosis

Hirasawa K et al, EHJ CVI, 2022

Patients underwent full-beat MDCT prior to TAVI
(n = 445)

Exclusion
- ✓ Patients with insufficient quality of images (n = 7)
- ✓ Intracardiac electronic devices (n = 22)
- ✓ History of valvular procedure (n = 5)
- ✓ Died from procedural complication of TAVI (n = 6)

Feasible population for cardiac damage staging by MDCT
(n = 405)



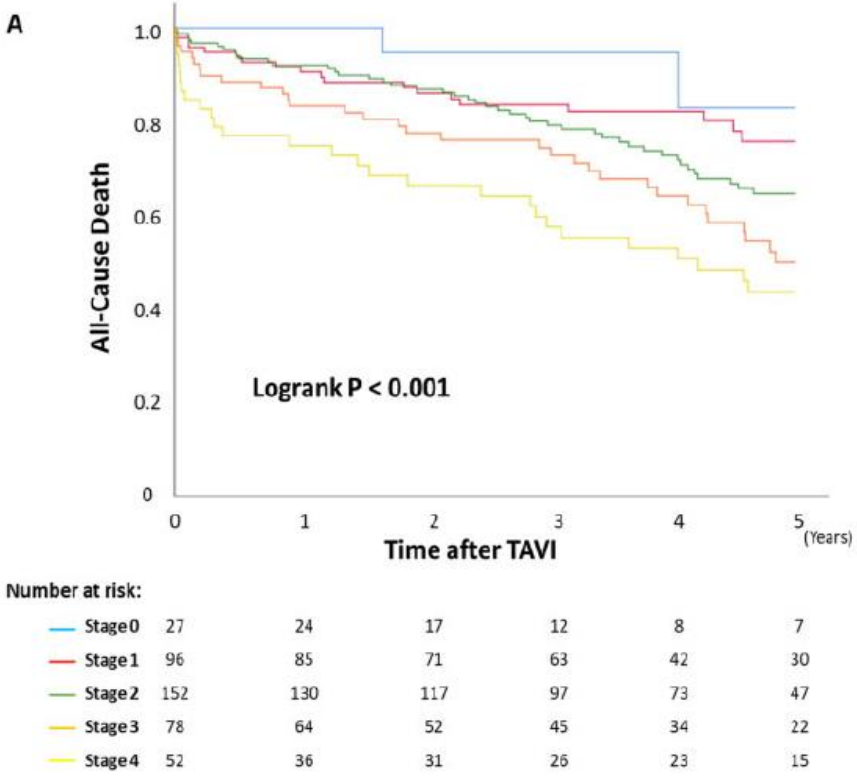
Prognostic implications of cardiac damage classification based on computed tomography in severe aortic stenosis

Hirasawa K et al, EHJ CVI, 2022

Table 3 The individual components according to cardiac damage staging using MDCT

Stage 0: no damage	27/405
Stage 1: LV damage	96/405
Increased LV mass index	
>79.2 g/m^2 for men or	331/405 (82%)
>63.8 g/m^2 for women	
LV ejection fraction < 50%	144/405 (36%)
Stage 2: LA or mitral valve damage	152/405
Indexed LA volume > 56 mL/m^2	236/405 (58%)
Presence of severe MAC	52/405 (13%)
Presence of AF at time of MDCT	80/405 (20%)
Stage 3: RA damage	78/405
Indexed RA volume > 70 mL/m^2	106/405 (26%)
Stage 4: RV damage	52/405
RV ejection fraction < 35%	52/405 (13%)

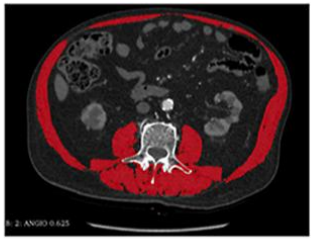
Values are expressed as *n*/*N* or *n* (%).
AF, atrial fibrillation; LA, left atrial; LV, left ventricular; MAC, mitral annular calcification; RA, right atrial; RV, right ventricular.



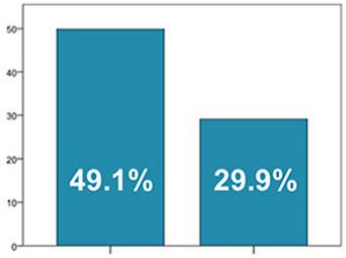
Impact of computed-tomography defined sarcopenia on outcomes of older adults undergoing transcatheter aortic valve implantation

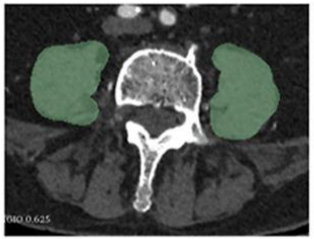
Gallone G et al, J cardiovasc CT, 2022

A. PREVALENCE OF CT-SARCOPENIA AMONG OLDER ADULTS UNDERGOING TAVR



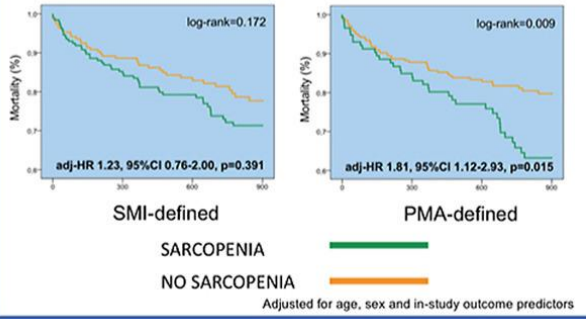
Skeletal muscle index (SMI)





Psoas muscle area (PMA)

B. ALL-CAUSE MORTALITY ACCORDING TO THE PRESENCE OF CT-SARCOPENIA FOLLOWING TAVR



C. VALUE OF PMA-SARCOPENIA OVER TAVR MORTALITY RISK PREDICTION TOOLS

MODEL	HR (95% CI)	p-value
Sarcopenia-PMA	1.82 (1.18-2.82)	**0.007**
STS PROM	1.02 (1.01-1.03)	0.001
Sarcopenia-PMA	1.66 (1.07-2.60)	**0.025**
Euroscore II	1.05 (1.02-1.7)	0.001
Sarcopenia-PMA	1.65 (1.06-2.55)	**0.025**
Charlson index	1.24 (1.10-1.40)	<0.001
Sarcopenia-PMA	1.69 (1.08-2.64)	**0.020**
TAVI2-Score	1.11 (0.93-1.32)	0.263

Conclusion

- Score calcique: marqueur pronostique majeur
- Distribution du calcium ?

- Nouveaux marqueurs à confirmer sur de larges cohortes

- Rôle pronostique: mortalité / succès procédural

- Rôle des marqueurs combinés dans la stratification du risque