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Quantification of abdominal aortic calcification: inherent measurement errors in current computed tomography imaging

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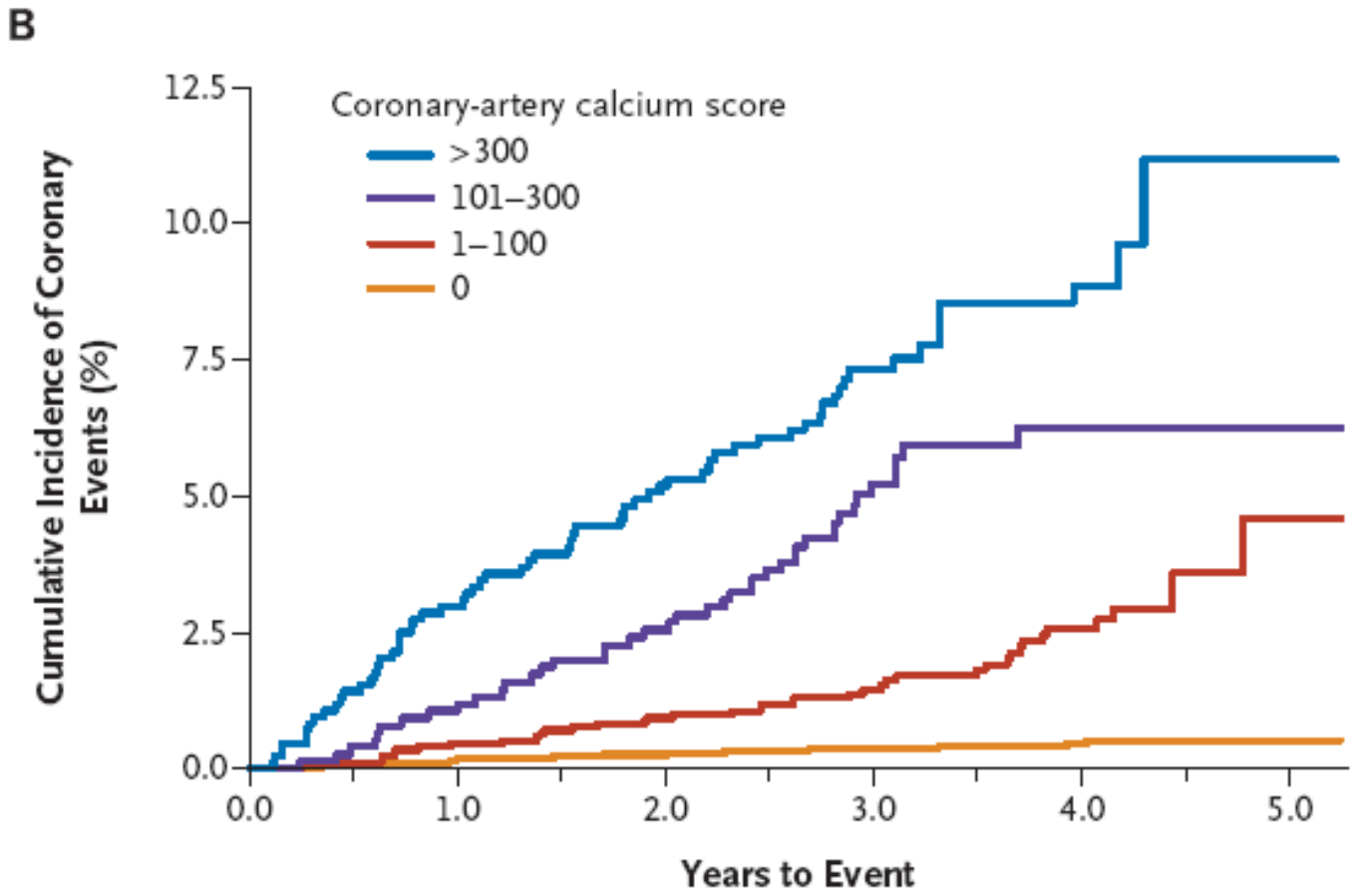
Disclosure of Interest

Speaker name: Clark Zeebregts

- I have the following potential conflicts of interest to report:
  - Consulting: Terumo Aortic (Vascutek)
  - Other(s): Received research grants from W.L. Gore & Associates, LeMaitre Vascular, Atrium Maquet Getinge Group, and Cook Medical

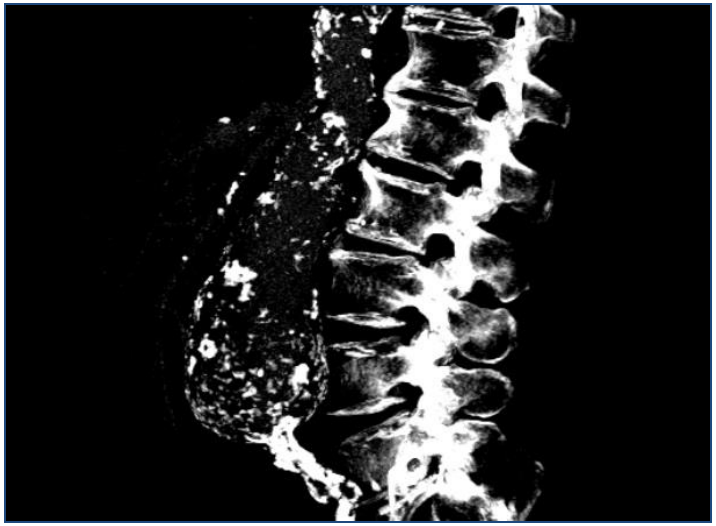
Coronary calcification



Detrano R, Guerci AD, Carr JJ, Burke G, Folsom AR, Liu K, Shea S, Szklo M, Bluemke DA, O'Leary DH, Tracy R, Watson K, Wong ND, Kronmal RA. Coronary calcium as a predictor of coronary events in four racial or ethnic groups. N Engl J Med 2008; 27: 358: 1336-45.

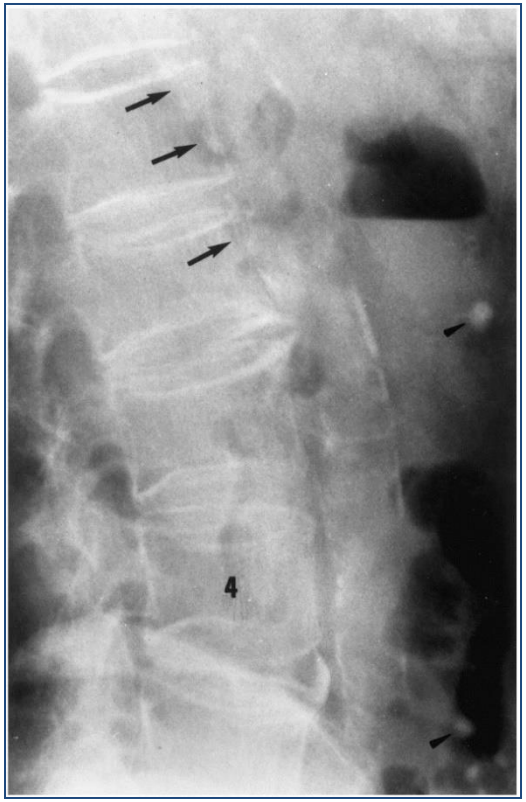
Abdominal aortic calcification (AAC)

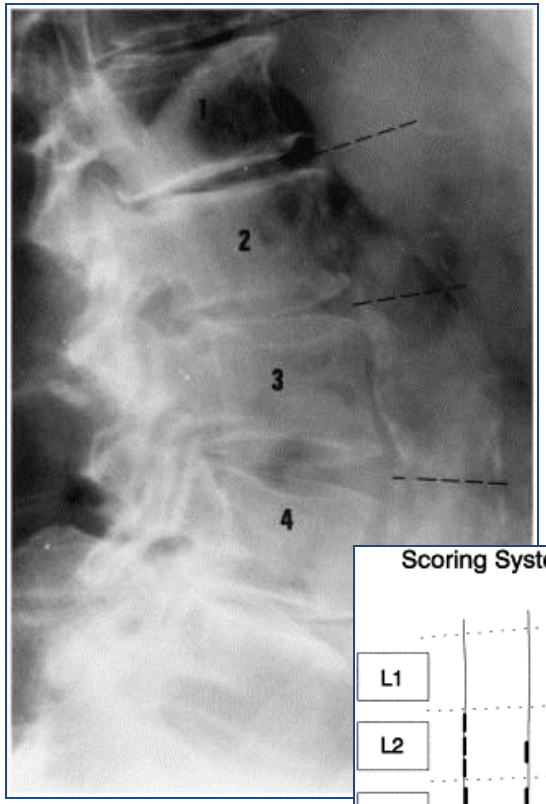
- Burden of aortic calcification correlates with the degree of atherosclerosis in other arteries.
- AAC is an independent predictor for cardiovascular disease.
- AAC can be detected by conventional x-ray, CT, but also with DEXA technique.



Clearly visible entity on CTA

Calcification score



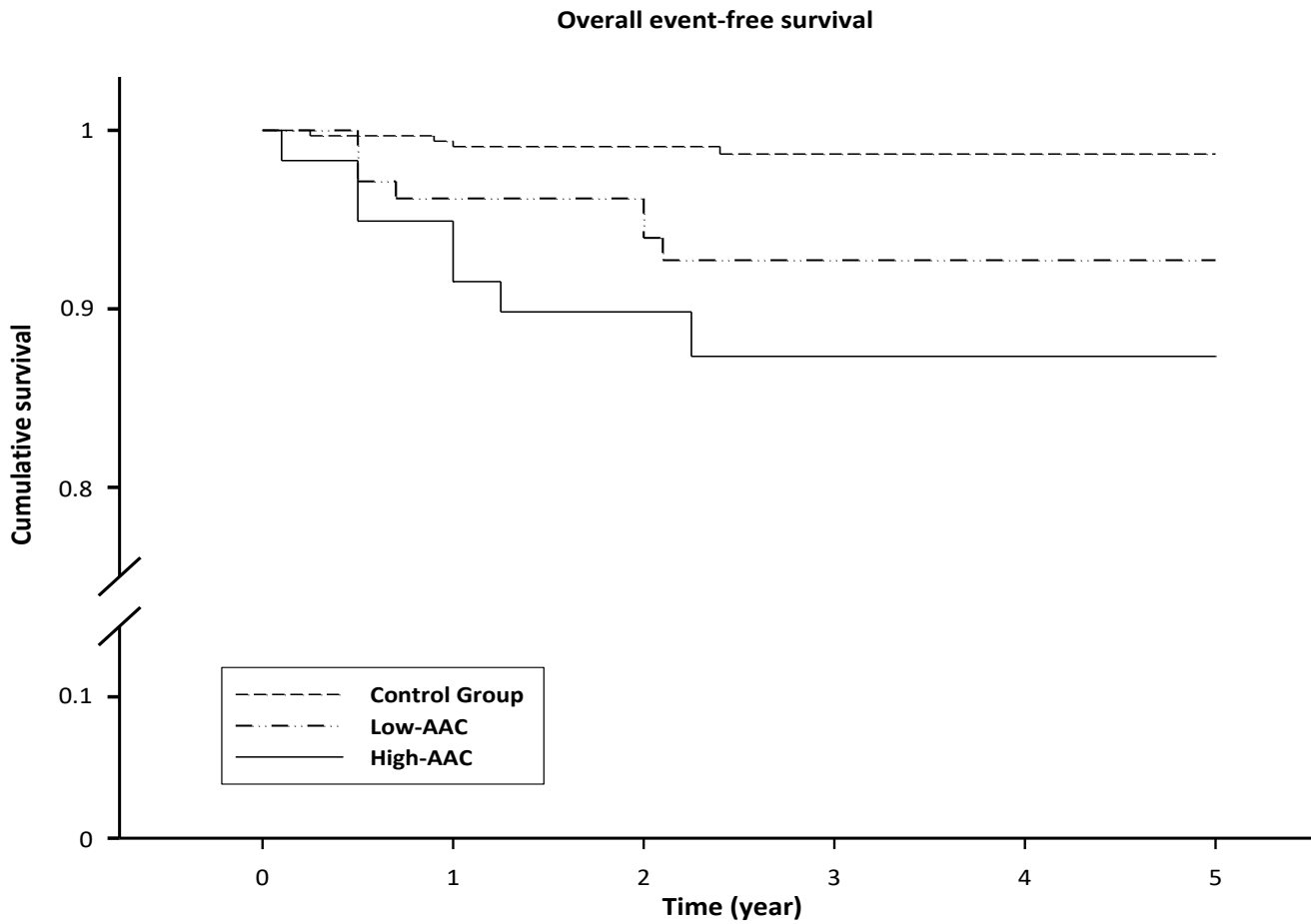


Scoring System for Lumbar Aortic Calcification

	Posterior	Anterior	Sum A+P	Affected A+P	Affected A or P
L1	0	0	0	0	0
L2	2	1	3	2	1
L3	3	3	6	2	1
L4	3	3	6	2	1
Total			15	6	3
Maximum			24	8	4

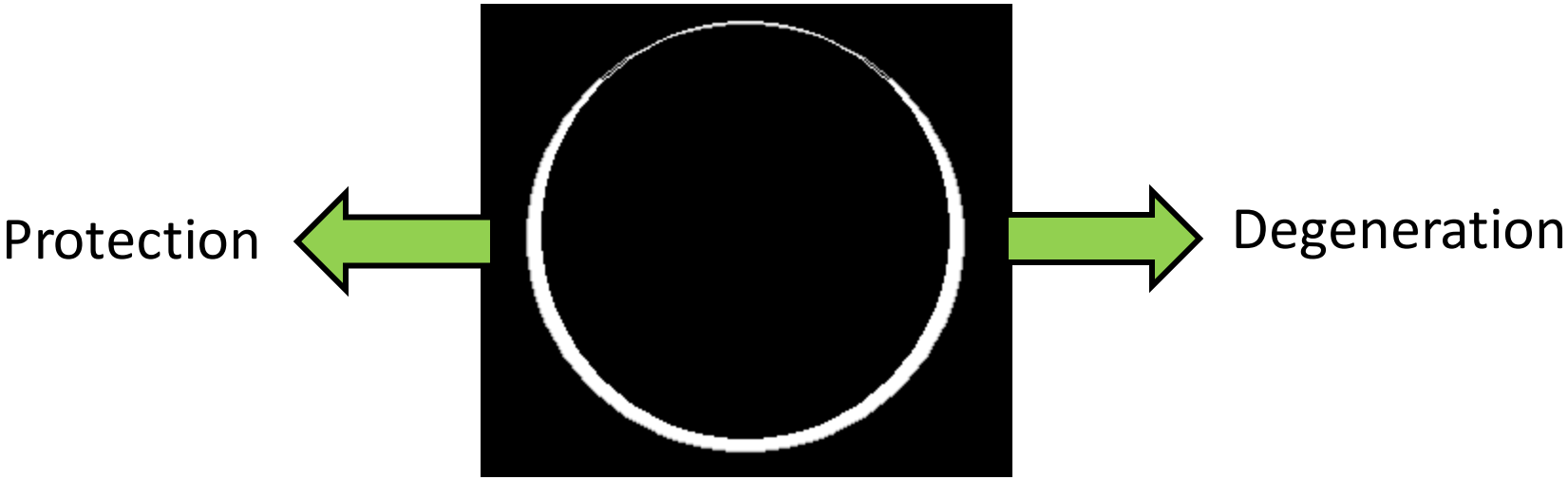
Kauppila LI, Polak JF, Cupples LA, Hannan MT, Kiel DP, Wilson PW. New indices to classify location, severity and progression of calcific lesions in the abdominal aorta: a 25-year follow-up study. Atherosclerosis 1997; 132: 245-50.

Calcification and cardiovascular risk



Golestani R, Tio RA, Zeebregts CJ, Zeilstra A, Dierckx RA, Boersma HH, Hillege HL, Slart RHJA. Abdominal aortic calcification detected by dual x-ray absorptiometry: a strong predictor for cardiovascular events. Ann Med 2010; 42: 539-45.

Calcification in the AAA wall



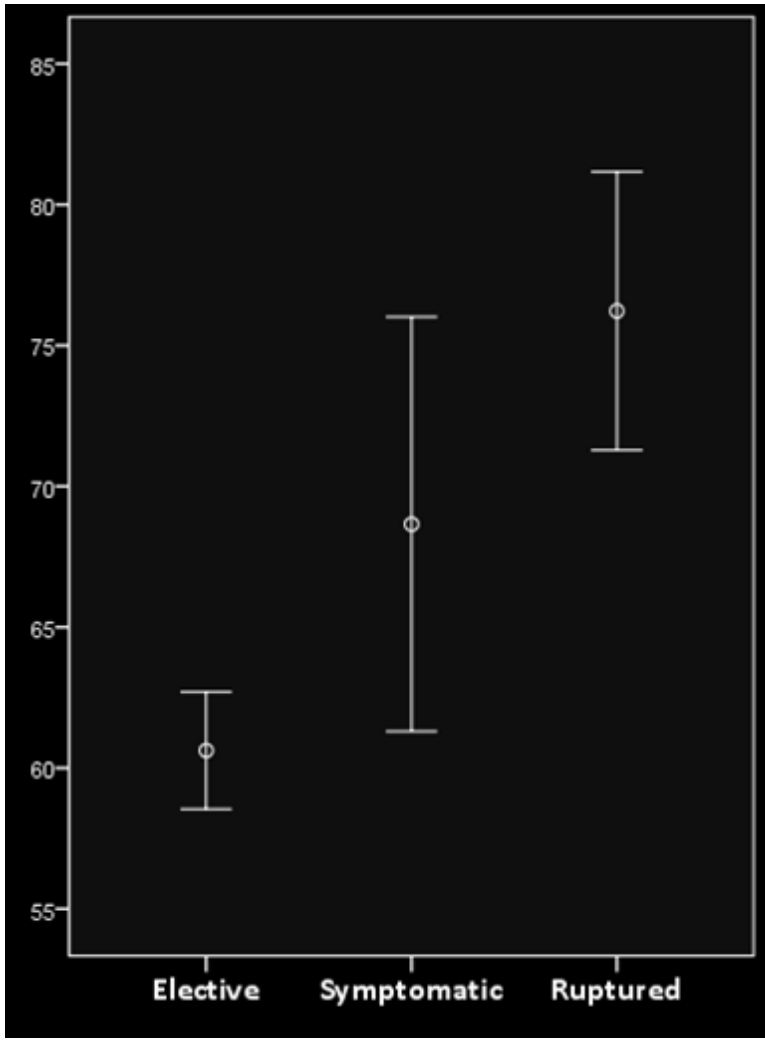
Population & methods

- Population:
  - Elective AAA; n = 129
  - Symptomatic, non-ruptured AAA; n = 28
  - Ruptured AAA; n = 73

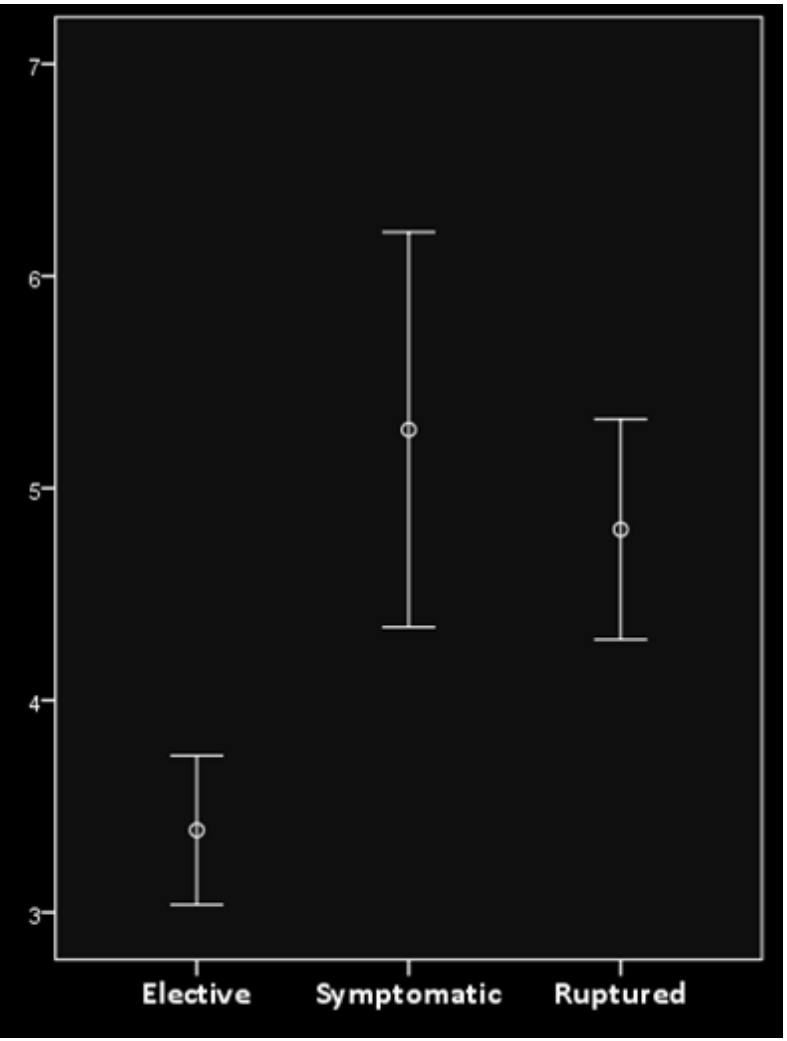
- Calcification measurements:
  - AAC-8 score
  - Visual calcification grading tool

Results: 95%-CI error bar

Diameter



Calcification score



Results: multivariate analysis

Variable	P-value	Odds ratio	95% CI
Gender (♀)	0.02	4.12	1.25-13.57
Diameter	< 0.001	1.05	1.03 – 1.08
AAC-8 score	< 0.001	1.38	1.18 – 1.61

Calcification quantification

- Semi-quantitative
  - AAC-8/24 score
  - Agatston score
  - % of aortic circumference
- Fully quantitative
  - Volume
  - Mass
- No clinical research on reliability of quantification tools

Phantom analysis - study design

- Two scanning protocols
  - Cardiac
  - Abdominal
- Two endpoints
  - Mass
  - Volume
- Five CT scans/protocol
  - 2-5 mm random movement between scans
- Two measurement tools
  - Aquarius iNtuition
  - 3Mensio Structural Heart
- Nine different calcium elements
  - Pre-established mass and volumes

Phantom analysis - results

- Abdominal versus cardiac protocol (mass):
  - Actual calcium mass:
    - 0.16 mg
  - Measured calcium mass:
    - 0.84 ± 1.02 versus 1.24 ± 1.38 mg, $p < .05$
- Mass measurements:
  - Between 39% underestimation and 1538% overestimation.
- Volume measurements:
  - Between 30% and 316% overestimation.
- Smaller calcium spots, higher error margin

Influence of contrast - study design

- Multi-phase CT scans
  - 50 clinical patients
  - Random selection
  - >65 years old
  - No implants in scanning area
- Non-enhanced versus contrast-enhanced
  - Subsequent scans within 30 minutes
  - Calcium volume and mass measurements
  - Three HU thresholds for calcium
    - 130, 299 & patient-dependent

Influence of contrast - results

- Non-enhanced versus contrast-enhanced calcium quantification:
  - Volume (mm^3): 1640 ± 1917 versus 2022 ± 2469, $p < .05$)
  - Mass (mg): 1174 ± 1288 versus 1005 ± 1337, $p < .05$)

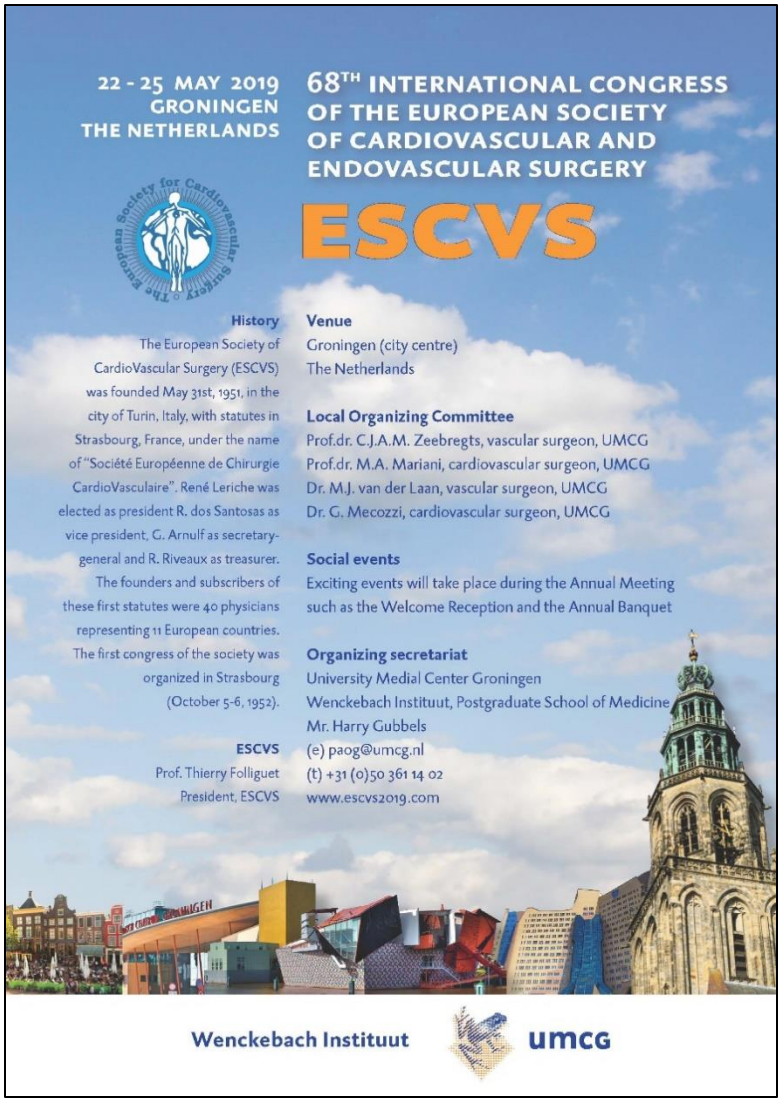
Calcium measurements tools: summary

- Aortic calcium volume and mass measurements are grossly erroneous and highly variable.
- Further worsening of the error margin for:
  - Smaller, lower weight calcium spots
  - In the presence of contrast
- Calcification measurement tools based on cardiac protocol measurements are non-representative.
- Measuring calcifications under contrast-enhanced conditions greatly impacts reliability.
- Not one currently used scoring tool for aortic calcification is demonstrably unaffected by the abovementioned issues.

Conclusions

- AAA diameter: insufficient
- Role of calcification: ambiguous
- Clinical value: promising
- Before further implementation harmonize scanning protocols and software packages

Acknowledgements



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Thank you for your attention and welcome to ESCVS 22-25 May 2019 in Groningen !