Abstract sessies NVVC Voorjaarscongres
Donderdag 20 april 2023
15:00 – 16:30 uur

SESSIE 3: IMAGING

Zaal: Boston 17/19	Voorzitters: dr. Berto Bouma, cardioloog, Amsterdam UMC en dr. Ivo van der Bilt, cardioloog, HagaZiekenhuis - locatie Leyweg
Spreker 1:	**Exercise-induced Cardiovascular Remodelling in a Large Cohort of Female, Elite Athletes: towards Sex-specific CMR Reference Ranges** *J.C. van Hattum (Amsterdam UMC, location University of Amsterdam, Amsterdam)*
Spreker 2:	**Relation between Coronary Artery Calcium Score and Cardiovascular Events in Hodgkin Lymphoma Survivors** *E.A.S. Polomski (Leids Universitair Medisch Centrum, Leiden)*
Spreker 3:	**Anatomical Features of Patent Foramen Ovale In Patients With Cryptogenic Stroke In Comparison to Autopsy Results** *L.S. Witte (Amsterdam UMC, Amsterdam)*
Spreker 4:	**Prevalence of Patent Foramen Ovale in Patients with Vasospastic Angina** *A. el Bouziani (Amsterdam UMC, location AMC, Amsterdam)*
Spreker 5:	**Diagnostic Performance of Quantitative Perfusion Cardiac Magnetic Resonance Imaging in Patients with Prior Coronary Artery Disease** *R. Hoek (Amsterdam University Medical Center, location VUmc, Amsterdam)*
Spreker 6:	**Echocardiographic Evaluation of the Left Ventricular Function in Patients with noncompaction cardiomyopathy: biplane method, wall motion score or global longitudinal strain?** *S. Mohamedhoesein (Erasmus MC, Rotterdam)*
Spreker 7:	**Coronary Artery Calcium Assessed on Routine Non-gated Chest CT as a Gatekeeper for Additional CCTA in Patients with Stable Chest Pain** *R.A. Groen (Leiden University Medical Centre, Leiden))*
Spreker 8:	**Elite Athlete Status, Gender and Mitchell Sports Classification Strongly Influence Native t1 Mapping Times** *J.J.N. Daems (Amsterdam University Medical Centers, Amsterdam)*

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Exercise-induced Cardiovascular Remodelling in a Large Cohort of Female, Elite Athletes: towards Sex-specific CMR Reference Ranges

Presenting author: J.C. van Hattum
Department: Cardiology

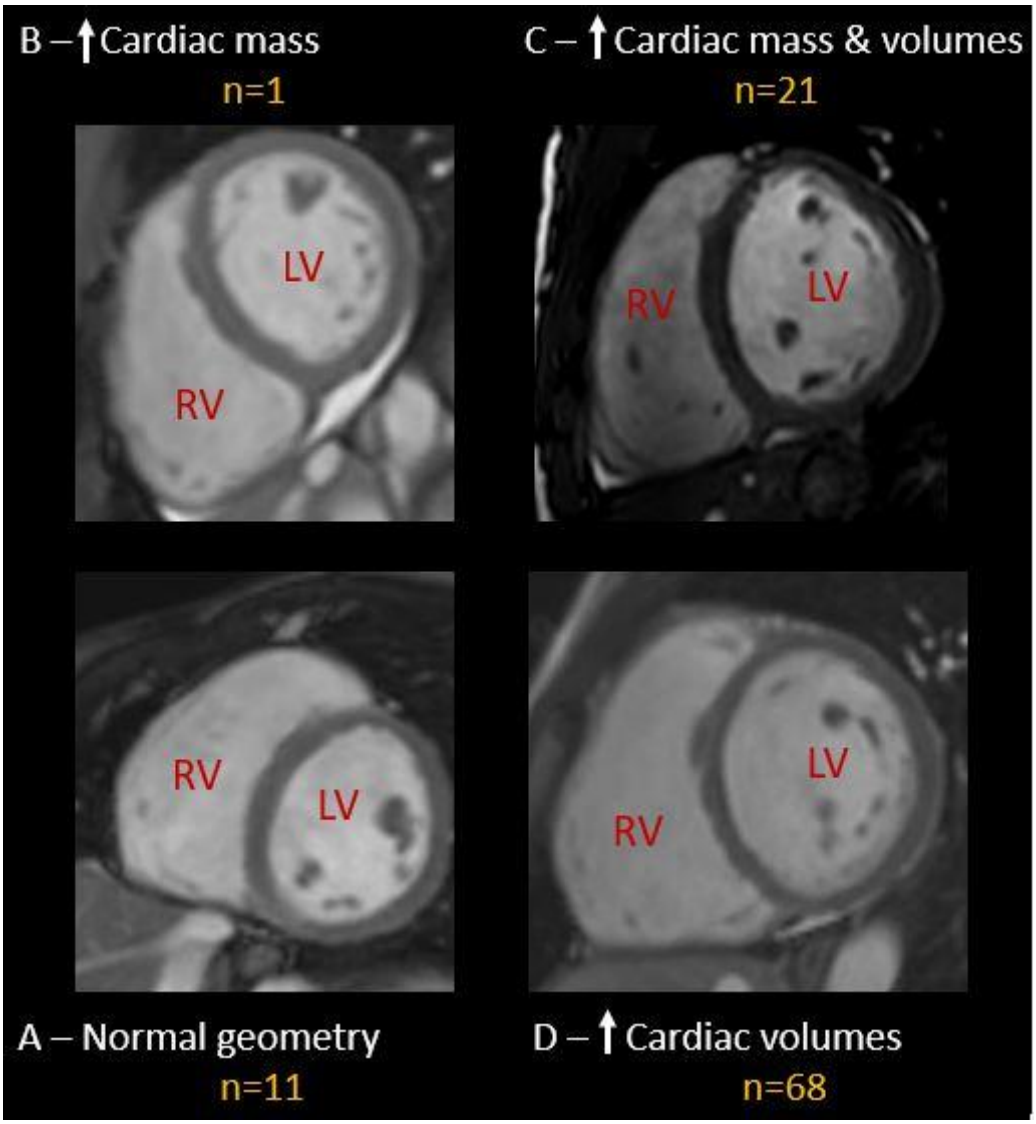
J.C. van Hattum (Amsterdam UMC, location University of Amsterdam, Amsterdam); J.C van Hattum (Amsterdam UMC, location University of Amsterdam, Amsterdam); M.A. van Diepen (Amsterdam UMC, location University of Amsterdam, Amsterdam); S.M. Verwijs (Amsterdam UMC, location University of Amsterdam, Amsterdam); J.J.N. Daems (Amsterdam UMC, location University of Amsterdam, Amsterdam); S.M. Boekholdt (Amsterdam UMC, location University of Amsterdam, Amsterdam); A. Van Randen (Amsterdam UMC, location University of Amsterdam, Amsterdam); R.N. Planken (Amsterdam UMC, location University of Amsterdam, Amsterdam); M. Groenink (Amsterdam UMC, location University of Amsterdam, Amsterdam); AJ. Nederveen (Amsterdam UMC, location University of Amsterdam, Amsterdam); M.H. Moen (Dutch National Olympic Committee & National Sports Federation, High Performance Team, Arnhem); A.A.M. Wilde (Amsterdam UMC, location University of Amsterdam, Amsterdam); Y.M. Pinto (Amsterdam UMC, location University of Amsterdam, Amsterdam); H.T. Jorstad (Amsterdam UMC, location University of Amsterdam, Amsterdam)

Purpose:
Differentiating between exercise-induced cardiac remodelling (EICR) and pathology constitutes a central challenge in sports cardiology. To facilitate this differentiation, reference ranges for cardiovascular magnetic resonance imaging (CMR) are needed. However, female athletes, and especially, female elite athletes with potentially the most outspoken adaptation, are severely underrepresented. To quantify EICR on CMR in a large cohort of female, elite athletes, compared with currently available reference values of the general female population.
Methods:
We performed a cross-sectional CMR analysis in female elite athletes aged ≥16 years, included in the ELITE cohort. We excluded athletes with known cardiovascular disease. The primary outcome was EICR quantification as BSA-indexed RV and LV end-diastolic volume (EDVi), LV wall mass (LVMi), LV remodelling index (LVMi/LVEDVi), and LV/RV ratio (LVEDi/RVEDVi). CMR was performed according to a uniform protocol, and included cine-imaging and delayed hyperenhancement, preferentially on 1.5T. A dedicated core lab analysed all CMRs in Circle Cardiovascular Imaging.
Results:
We included 102 female elite athletes, 97% Caucasian, mean age of 26.3 ±5.0, BSA 1.79 ±0.14 m2, and mean professional athlete years of 10.3 ±5. Main athlete disciplines (≥10 hours/week) were field hockey (15%), rowing (13%), road cycling (12%), and European-style football (10%). Female elite athletes had marked EICR as compared with general population reference values, with higher LVEDVi (108 ±13.9 vs 69 ±12 ml/m2, $p<0.05$), RVEDVi (110 ±15.3 vs 76 ±14 ml/m2, $p<0.05$), and LVMi (49.9 ±11.2 vs 45 ±7 g/m2, $p<0.05$) (Figure 1). LV remodelling showed a lower LVM/LVEDV ratio (0.46 ±0.08 vs 0.7 ±0.1 ml) compared to the general population, with balanced dilatation (LVEDV/RVEDV=0.98 ±0.05). In general, we observed EICR as increased cardiac volumes in 67% (n=68), increased cardiac volumes and mass in 21% (n=21) lone increase in cardiac mass in 1% (n=1), with 11% (n=11) demonstrating normal geometry (Figure 1).
Conclusion:
EICR on CMR in female, elite athletes is mainly characterised by isolated increased

volumes, with a considerable proportion (11%) demonstrating no EICR. Compared with the general population, female athletes have larger cardiac ventricular volumes and wall mass. Our results constitute a first step towards sex-specific CMR reference ranges for female athletes.

Keywords:
Exercised-induced cardiac remodelling, Female elite athletes, CMR

Figure:
Figure 1. CMR end-diastolic short axis basal slice images of exercise-induced cardiac remodelling in female elite athletes: A) CMR image showing normal geometry, B) CMR image showing increased cardiac mass, C) CMR image showing both increased cardiac volumes and mass, D) CMR image showing increased cardiac volumes. LV = left ventricle, RV = right ventricle.



Relation between Coronary Artery Calcium Score and Cardiovascular Events in Hodgkin Lymphoma Survivors

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Presenting author: E.A.S. Polomski
Department: Hartziekten

E.A.S. Polomski (Leids Universitair Medisch Centrum, Leiden); E.A.S. Polomski (LUMC, Leiden); J.C. Heemelaar (LUMC, Leiden); M.A. de Graaf (LUMC, Leiden); A.D.G. Krol (AVL, Amsterdam); M. Louwerens (LUMC, Leiden); J.L. Stöger (LUMC, Leiden); M.J. Schalij (LUMC, Leiden); J.W. Jukema (LUMC, Leiden); M.L. Antoni (LUMC, Leiden)*
**Per 01-03-2023 LUMC, Leiden*

Purpose:
Thoracic radiotherapy is still one of the corner stones of Hodgkin lymphoma (HL) treatment, but is associated with increased risk of cardiovascular events. This study aims to evaluate the presence and distribution of coronary artery calcium in relation to cardiovascular events in HL patients treated with thoracic radiotherapy compared to a non-cancer control group.
Methods:
HL patients treated with thoracic radiotherapy, who underwent evaluation for asymptomatic coronary artery disease with coronary computed tomography angiography >10 years after irradiation were included. HL patients were matched 1:1 to non-cancer patients for gender, age, cardiovascular risk factors and statin use. Differences in coronary artery calcium score (CACS), plaque composition and cardiovascular events between the two groups were compared.
Results:
97 patients with prior HL diagnosis and 97 patients with no history of cancer were included. Elevated CACS was seen in 50.5% of the HL patients and 30.9% of the control patients. HL survivors had an odds ratio of 2.28 [95% CI: 1.22 – 4.28] for having a CACS >0 compared to the matched population (p=0.006). Prevalence of CACS above the 90th percentile differed significantly: 17.5% in HL survivors versus 4.7% in the matched population (p=0.005). Coronary artery plaques were more prevalent in the HL population than in the control population (39.2% versus 15.5% respectively, p<0.001). Nine HL patients experienced an event during follow-up including two patients with a CACS of zero. No events were observed in the control population.
Conclusion:
In a matched study population, HL survivors have a higher prevalence of a CACS >0 and an increased risk of cardiovascular events after thoracic irradiation compared to a matched non-cancer control group.

Keywords:
Hodgkin lymphoma, thoracic radiotherapy, coronary artery disease, ,

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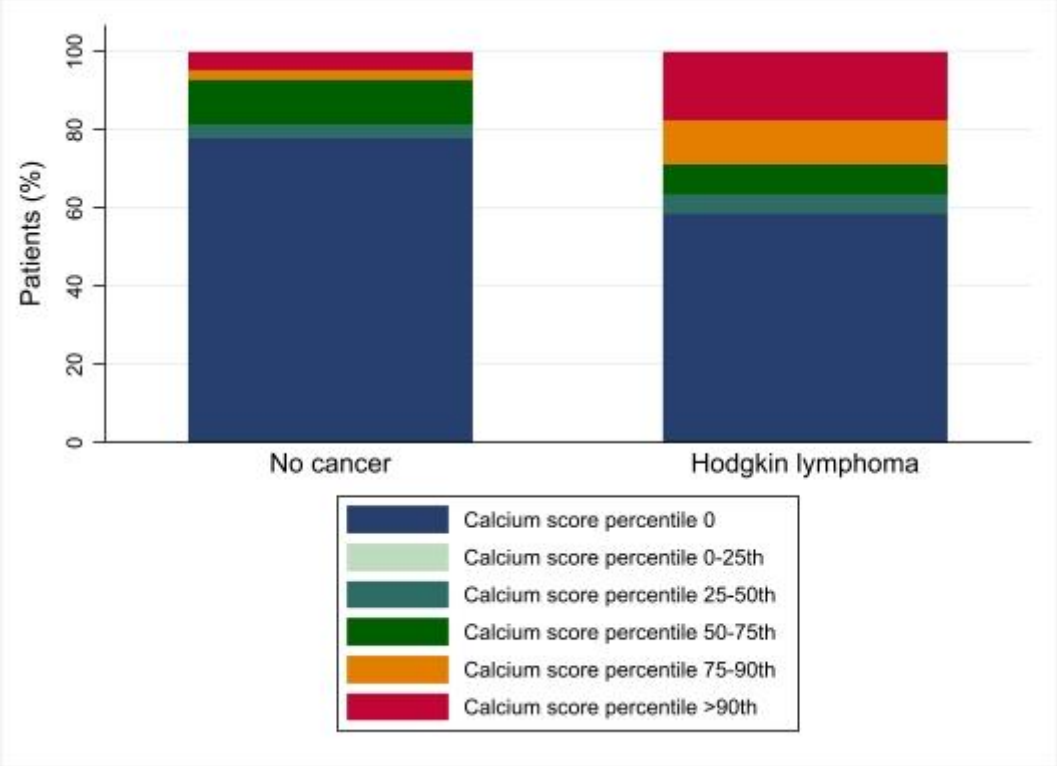
Figure:
Figure 1 shows a bar chart for the distribution of calcium score percentiles in both patient groups.



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Anatomical Features of Patent Foramen Ovale In Patients With Cryptogenic Stroke In Comparison to Autopsy Results

Presenting author: L.S. Witte
Department: Cardiology

L.S. Witte (Amsterdam UMC, Amsterdam); L.S. Witte (Amsterdam UMC, Amsterdam); M.H.M. Immens (Radboud UMC, Nijmegen); A. el Bouziani (Amsterdam UMC, Amsterdam); A. Duijnhouwer (Radboud UMC, Nijmegen); B.J. Bouma (Amsterdam UMC, Amsterdam); F.E. de Leeuw (Radboud UMC, Nijmegen); R.J. de Winter (Amsterdam UMC, Amsterdam); T.J.F. ten Cate (Radboud UMC, Nijmegen)

Purpose:
The prevalence of patent foramen ovale (PFO) found in autopsy studies is approximately 25% but not all patients with PFO will suffer from a PFO-associated stroke.). The prevalence of a PFO in autopsy studies is approximately 25-30%, suggesting that the a priori chance of finding a possible “bystander-PFO” in young stroke victims is substantial. In this study we assessed the anatomical differences between PFO found during autopsy and PFO in patients with cryptogenic stroke.
Methods:
All consecutive patients that underwent PFO closure were retrospectively included. Anatomical PFO characteristics, including PFO diameter, tunnel length and the presence of atrial septal aneurysm, were measured with TEE during the closure procedure and analyzed by two cardiologists. Patients were divided in two groups depending on how the PFO diameter was measured, unstretched (n=119) and stretched (n=109).
Results:
In total 228 patients were enrolled. The mean age was 43±11 years, 116 patients (50.9%) were male and the mean RoPE-score was 7.0±1.4. The mean PFO diameter was 5.4±2.6mm in the unstretched group and 10.9±3.6mm in the stretched group compared to 4.9±2.6mm in previous autopsy (p=0.192 and p<0.001, respectively). The percentage of patients with a PFO size larger than 10mm was 2% in autopsy compared to 6% in the unstretched group (p=0.109) and 52% in the stretched group (p<0.001). The mean PFO tunnel length in our combined cohort was 7.8±2.9mm.
Conclusion:
The difference in PFO diameter found in this study indicates that PFOs found during published autopsy series, which are present in approximately 25-30% of the population, are significantly smaller than PFOs related to cryptogenic stroke. The exact prevalence of PFOs with dimensions similar to those related to cryptogenic stroke remains unknown, but is likely to be much smaller than 25-30%. Future studies should define which characteristics could classify or rule out a PFO prone for associated clinical conditions, such as cryptogenic stroke.

Keywords:
Patent Foramen Ovale, Cryptogenic Stroke,

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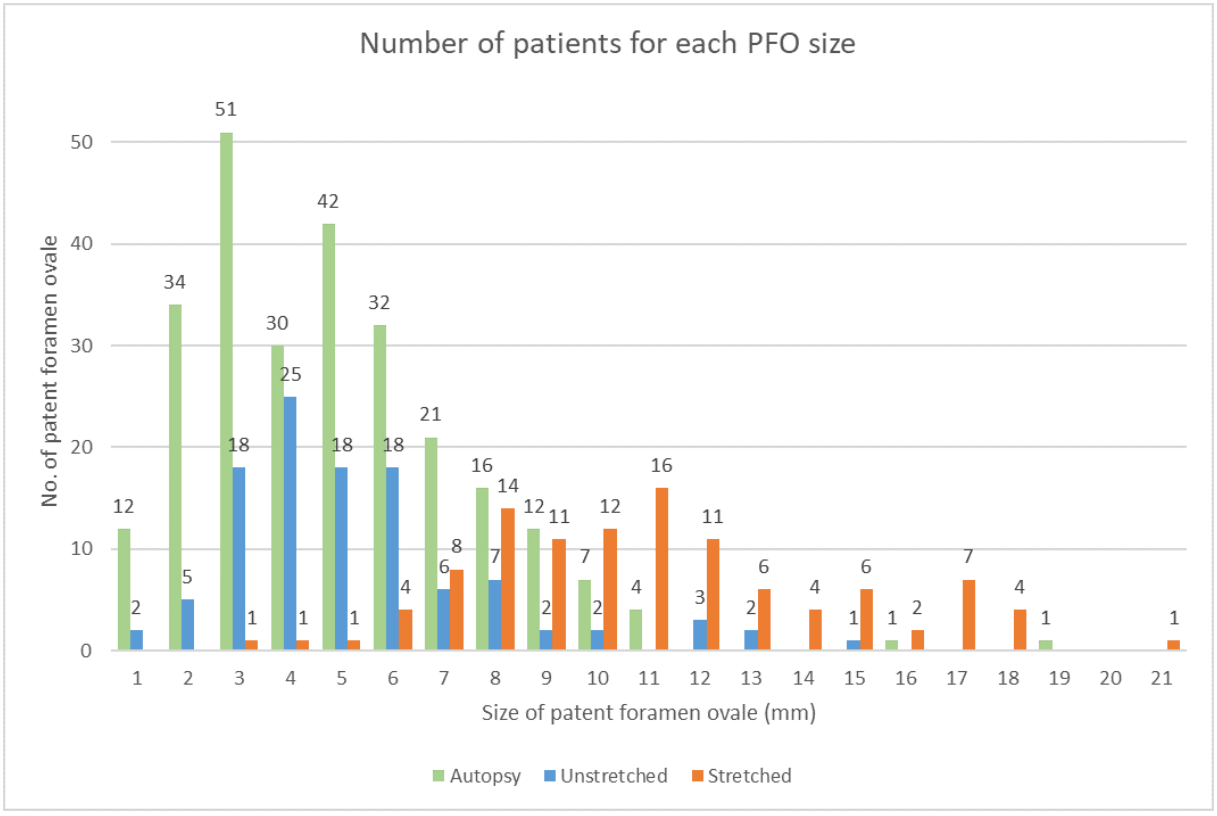
Figure:
Figure 3. Distribution of the number of patients for each PFO size for PFOs found during autopsy, unstretched PFOs and stretched PFOs. The mean PFO diameter was 4.9mm, 5.4mm and 10.9mm, respectively. The percentage of patients with a PFO size larger than 10mm was 2%, 6% and 52% respectively.



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Prevalence of Patent Foramen Ovale in Patients with Vasospastic Angina

Presenting author: A. el Bouziani
Department: Congenital interventional cardiology

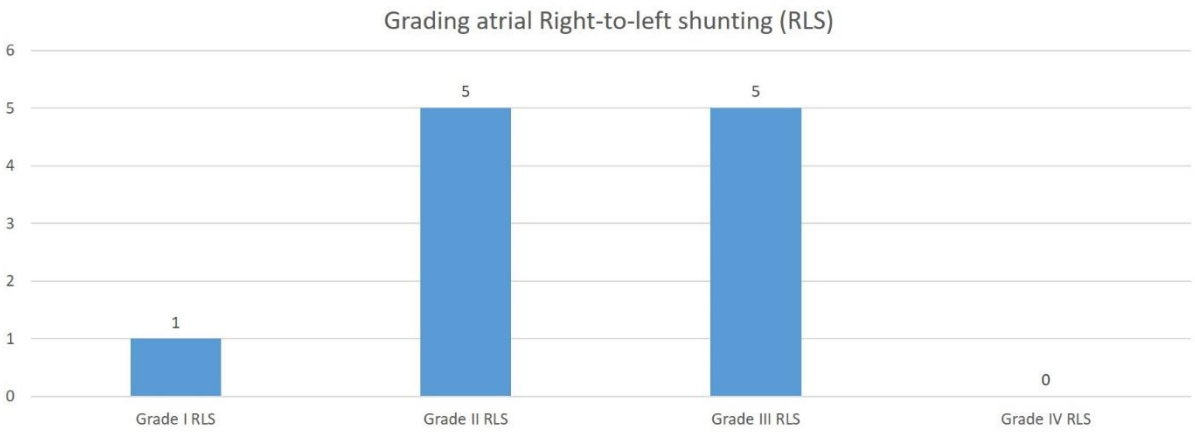
A. el Bouziani (Amsterdam UMC, location AMC, Amsterdam); A. el Bouziani (Amsterdam UMC, location AMC, Amsterdam); L.S. Witte (Amsterdam UMC, location AMC, Amsterdam); R.G.T. Feenstra (Amsterdam UMC, location AMC, Amsterdam); M.P.L. Renkens (Amsterdam UMC, location AMC, Amsterdam); J.J. Piek (Amsterdam UMC, location AMC, Amsterdam); B.J. Bouma (Amsterdam UMC, location AMC, Amsterdam); R.J. de Winter (Amsterdam UMC, location AMC, Amsterdam); M.A.M. Beijk (Amsterdam UMC, location AMC, Amsterdam)

Purpose:
The aim of this study is to assess the prevalence of patent foramen ovale (PFO) and right-to-left shunting (RLS) in 50 patients with documented coronary artery vasospasm. Prevalence of PFO in the general population is estimated to be 20 to 25%. A recent study demonstrated an association between migraine and coronary artery vasospasm, suggesting that RLS through a PFO might be a trigger for complaints due to coronary spasm. However, currently the prevalence of PFO in patients with coronary artery vasospasm is unknown.
Methods:
This is a single-center, prospective, cohort study with an open label follow-up at 1 month. All patients known with angina and documented coronary artery vasospasm underwent a complete transthoracic echocardiography (TTE) including agitated-saline injection. Coronary artery vasospasm is diagnosed in an earlier stage with an intracoronary acetylcholine provocation testing after CAG was performed. Right-to-left shunting (RLS) was semi quantified graded (grade 0 = no microbubbles, grade I = <5 microbubbles (mild), grade II = 5-25 microbubbles (moderate), grade III = > 25 microbubbles (severe) and grade IV = opacification of the entire left atrium). The RLS is assessed within the first four cardiac cycles after opacification of the right atrium. If there was no RLS observable, than the injection with agitated-saline was repeated performing the Vasalva manoeuvre. Afterwards the Seattle Angina Questionnaire and the Migraine Disability Assessment Questionnaire was used to survey patients at baseline and at 1 month. They report on general well-being, daily activities, episodes of angina and migraine.
Results:
Up to now 45 patients have undergone TTE with agitated-saline. The mean age was 57 ± 10 years and 84% were female patients. PFO and RLS was observed in 11 patients (24%), whereas one patient had grade I, 5 patients had grade II and 5 patients had grade III right-to-left shunting. Opacification of the left atrium/ventricle (grade IV) was not detected. Of those 11 patients, 5 patients had epicardial vasospasm, 4 patients had microvascular vasospasm/dysfunction and 2 patients had both types of non-obstructive coronary artery disease. None of the patients with RLS had significant obstructive coronary artery disease. The Migraine Disability Assessment Questionnaire showed that 45% of the patients with RLS had migraine headache at baseline, whereas 5 of them reported migraine with aura. The Seattle Angina Questionnaire demonstrated no significant difference in the angina frequency scale (p=0.612) and quality of life scale (p=0.138) between patients with and without RLS.
Conclusion:
The current study so far, showed that prevalence of PFO in patients with documented coronary artery vasospasm is comparable with the prevalence in the general population. However, it remains unclear what the role is of RLS in those patients. Future studies are

needed in order to investigate RLS as a trigger for coronary artery vasospasm.

Keywords:
Prevalence, PFO, Vasospastic angina

Figure:



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Diagnostic Performance of Quantitative Perfusion Cardiac Magnetic Resonance Imaging in Patients with Prior Coronary Artery Disease

Presenting author: R. Hoek
Department: Cardiology

R. Hoek (Amsterdam University Medical Center, location VUmc, Amsterdam); S. Borodzicz-Jazdzyk (Amsterdam University Medical Center, location VUmc, Amsterdam); P.A. van Diemen (Amsterdam University Medical Center, location VUmc, Amsterdam); Y.B.O. Somsen (Amsterdam University Medical Center, location VUmc, Amsterdam); R.W. de Winter (Amsterdam University Medical Center, location VUmc, Amsterdam); R.A. Jukema (Amsterdam University Medical Center, location VUmc, Amsterdam); J.W.R. Twisk (Amsterdam University Medical Center, location VUmc, Amsterdam); P.G. Raijmakers (Amsterdam University Medical Center, location VUmc, Amsterdam); J. Knuuti (Amsterdam University Medical Center, location VUmc, Amsterdam); T. Maaniitty (Amsterdam University Medical Center, location VUmc, Amsterdam); R.S. Underwood (Amsterdam University Medical Center, location VUmc, Amsterdam); E. Nagel (Amsterdam University Medical Center, location VUmc, Amsterdam); L.F.H.J. Robbers (Amsterdam University Medical Center, location VUmc, Amsterdam); A. Demirkiran (Amsterdam University Medical Center, location VUmc, Amsterdam); M.B. von Bartheld (Amsterdam University Medical Center, location VUmc, Amsterdam); R.S. Driessen (Amsterdam University Medical Center, location VUmc, Amsterdam); I. Danad (Amsterdam University Medical Center, location VUmc, Amsterdam); M.J.W. Götte (Amsterdam University Medical Center, location VUmc, Amsterdam); P. Knaapen (Amsterdam University Medical Center, location VUmc, Amsterdam)

Purpose:
Background: The diagnostic performance of quantitative perfusion cardiac magnetic resonance (QP-CMR) imaging has scarcely been evaluated in patients with a history of coronary artery disease (CAD) and new onset angina.
Objectives: To compare the diagnostic performance of QP-CMR for detecting fractional flow reserve (FFR) defined hemodynamically significant CAD with visual CMR assessment (v-CMR) and [15O]H2O positron emission tomography (PET) imaging in patients with prior CAD.
Methods:
This PACIFIC-2 substudy included 138 symptomatic chronic coronary symptom patients with prior myocardial infarction (MI) and/or percutaneous coronary intervention (PCI). All patients underwent dual-sequence, single bolus perfusion CMR and [15O]H2O PET imaging followed by invasive coronary angiography with three-vessel FFR. Hemodynamically significant CAD was defined as an FFR ≤0.80. For QP-CMR, an optimal regional stress myocardial blood flow (MBF) cutoff value to detect significant CAD was defined.
Results:
For QP-CMR, a regional stress MBF ≤1.43 ml/min/g defined presence of myocardial ischemia. QP-CMR, v-CMR and PET exhibited a sensitivity of 67%, 68%, and 81%, respectively, whereas specificity was 57%, 65%, and 64%. Sensitivity of QP-CMR was lower than PET (p=0.033), whereas specificity of QP-CMR and PET was comparable. Diagnostic accuracy and AUC of QP-CMR (63% and 0.65) was comparable to v-CMR (67% and 0.70, both p>0.999), and lower than PET (75%, p=0.048 and 0.79, p=0.020).
Conclusion:
In patients with prior MI and/or PCI, diagnostic performance of QP-CMR was comparable to v-CMR and lower when compared to PET for the detection of hemodynamically significant

CAD as defined by FFR.

Keywords:
Quantitative Perfusion Cardiac Magnetic Resonance Imaging, Myocardial Perfusion Imaging, Fractional Flow Reserve

Figure:
This PACIFIC-2 substudy compared the diagnostic performance of quantitative perfusion CMR, visual CMR and quantitative PET perfusion imaging for detecting hemodynamically significant CAD in patients with prior MI and/or PCI. An average stress MBF ≤1.43 ml/min/g on QP-CMR, a visually assessed perfusion defect on v-CMR, and a stress MBF ≤2.3 ml/min/g in 2 adjacent segments on PET were used to define presence of ischemia. In AUC comparison, diagnostic performance of QP-CMR was comparable to v-CMR and lower when compared to PET.

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Echocardiographic Evaluation of the Left Ventricular Function in Patients with noncompaction cardiomyopathy: biplane method, wall motion score or global longitudinal strain?

Presenting author: S. Mohamedhoesein
Department: Cardiology

S. Mohamedhoesein (Erasmus MC, Rotterdam); S. Mohamedhoesein (Erasmus MC, Rotterdam); M. Tukker (Erasmus MC, Rotterdam); E. Kaya (Erasmus MC, Rotterdam; St Antonius, Nieuwegein); K. Caliskan (Erasmus MC, Rotterdam)

Purpose:
Accurate assessment of the (subclinical) LV dysfunction in NCCM patients could improve non-invasive monitoring of disease progression, risk stratification
Methods:
We reviewed the echocardiographic images of 67 patients (54% male, median age 48 year [22-73]. LV function was assessed by conventional biplane disk summation, wall motion score (WMS), and global longitudinal strain (GLS). LV function was considered abnormal if LV ejection fraction (LVEF) <50% and GLS >-18.9%.
Results:
LV function measured by biplane vs WMS showed significantly lower LV EF with WMS (p value: 0.0016; Figure), while the average GLS in all patients was -11.0%, SD ±3.8 (normal values: -18.9%; p-value: p<0.001). By dichotomizing the group into LVEF <50% vs. ≥50%, biplane EF was abnormal in 68.7%, while this was with WMS 88.1% and by GLS 100%. In patient with EF <50% compared to ≥ 50% GLS in low biplane EF group was: -9.3%, SD ±3.0 vs -14.5%, SD ±2.9 (p<0.001). In the WMS EF was this respectively -10.3, SD ±3.6% versus -
15.5, SD ±1.5 (p<0.001).
Conclusion:
The systolic LV dysfunction in patients with NCCM found by WMS and GLS was significantly lower compared to routine biplane EF measurement suggesting that WMS and GLS measurement are much more potential prognostic tool. Given the correct execution of WMS is limited by the assessor's experience, estimation of the LV function with GLS are probably most reliable. Future research should expel whether these results are representative in a larger group of patients and correlates with the clinically relevant endpoints.

Keywords:
Cardiomyopathy, Echocardiography, Ventricular function

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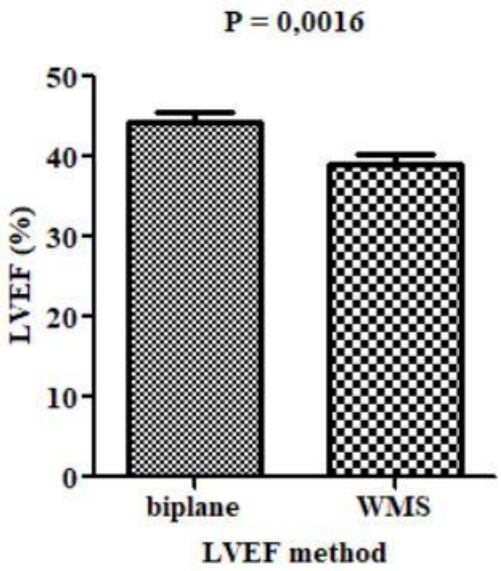
Figure:
LVEF measured by WMS and biplane method.



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Coronary Artery Calcium Assessed on Routine Non-gated Chest CT as a Gatekeeper for Additional CCTA in Patients with Stable Chest Pain

Presenting author: R.A. Groen
Department: Cardiology

R.A. Groen (Leiden University Medical Centre, Leiden); R.A. Groen BSc (Leiden University Medical Centre, Leiden); P.R.M. van Dijkman MD PhD (Leiden University Medical Centre, Leiden); J.W. Jukema MD PhD (Leiden University Medical Centre, Leiden); J.J. Bax MD PhD (Leiden University Medical Centre, Leiden); H.J. Lamb MD PhD (Leiden University Medical Centre, Leiden); M.A. de Graaf MD PhD (Leiden University Medical Centre, Leiden)

Purpose:
Currently applied risk assessment methods in coronary artery disease (CAD) often overestimate patients' risk for obstructive CAD. Assessment of coronary artery calcium (CAC) can be applied to enhance patient-tailored risk estimation. In ~10% of patients presenting with stable chest pain a non-gated chest computed tomography (CT) has been previously performed, suitable for CAC assessment. This is the first study to investigate the clinical utility of CAC assessment on non-gated chest CT for risk assessment of obstructive CAD.
Methods:
All patients referred for coronary CT angiography (CCTA), in whom a previous non-gated chest CT was performed were included in this analysis. For assessment of the extent of CAC, an ordinal score was applied. CAD was assessed on CCTA, with obstructive CAD defined as stenosis of ≥70%. Patients were stratified into groups according to CAC severity and percentages of patients with obstructive CAD were compared between the groups.
Results:
In total, 181 patients between 30-88 years were included. A significant difference in the percentage of obstructive CAD between the CAC groups was observed ($p<0.01$). A calcium score of 0 ruled out obstructive CAD with 100% certainty, irrespective of sex, pre-test probability, type of complaints, and the number of risk factors. Furthermore, in patients with low – intermediate PTP or non-anginal complaints, a mild CAC score ruled out obstructive CAD with 100% certainty.
Conclusion:
CAC assessment on non-gated chest CT can safely rule out obstructive CAD in patients presenting with stable chest pain and can therefore function as a radiation-free and cost-free gatekeeper for additional imaging.

Keywords:
coronary artery disease, coronary calcium, non-gated computed tomography

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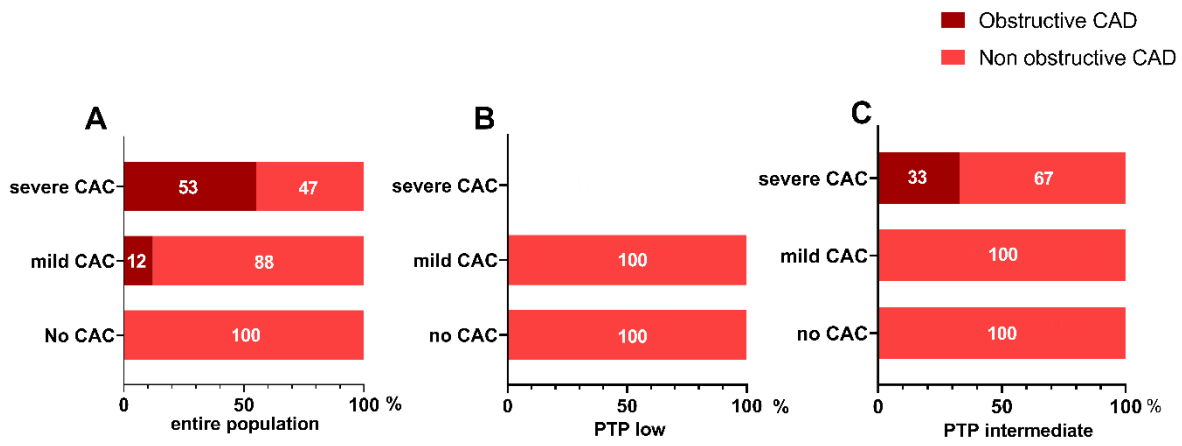
Figure:
Figure1. CCTA results for the entire study population and pre-test probability categories
A: Distribution of obstructive vs no obstructive CAD in all patients
B: Distribution of obstructive vs no obstructive CAD in patients with a PTP of ≤5%
C: Distribution of obstructive vs no obstructive CAD in patients with a PTP of 6-15%



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Elite Athlete Status, Gender and Mitchell Sports Classification Strongly Influence Native t1 Mapping Times

Presenting author: J.J.N. Daems
Department: Sport Cardiology

J.J.N. Daems (Amsterdam University Medical Centers, Amsterdam); J.J.N. Daems (Amsterdam University Medical Centers, Amsterdam); S.M. Verwijs (Amsterdam University Medical Centers, Amsterdam); R.D. Janssen (Amsterdam University Medical Centers, Amsterdam); J.C. Van Hattum (Amsterdam University Medical Centers, Amsterdam); S.M. Boekholdt (Amsterdam University Medical Centers, Amsterdam); A. van Randen (Amsterdam University Medical Centers, Amsterdam); R.N. Planken (Amsterdam University Medical Centers, Amsterdam); R.D. van Luijk (Amsterdam University Medical Centers, Amsterdam); M.H. Moen (Amsterdam University Medical Centers, Amsterdam); A. Nederveen (Amsterdam University Medical Centers, Amsterdam); M. Groenink (Amsterdam University Medical Centers, Amsterdam); Y.M. Pinto (Amsterdam University Medical Centers, Amsterdam); H.T. Jorstad (Amsterdam University Medical Centers, Amsterdam)

Purpose:
Cardiac magnetic resonance imaging (CMR) T1 mapping is an established tool for tissue characterisation. This is of particular interest in athletes as differentiation of the 'grey zone' between physiological adaptation to sports and pathology can be highly challenging. To correctly interpret individual T1 times, T1 times are conventionally compared to normal values derived from healthy controls. However, whether these values can be applied to elite athletes with different types of cardiac adaptation is unknown.
Methods:
This is a cross-sectional analysis of elite athletes included in the ELITE cohort. ELITE collects the preparticipation cardiovascular screenings data from all athletes that perform at the highest national, international and/or Olympic level in the Netherlands. All athletes were sixteen years or older. The screening includes cardiovascular magnetic resonance imaging on a Siemens Avanto fit 1.5T machine with cine-imaging, delayed hyperenhancement and a three-pulse shortened modified look-locker inversion recovery 5(3)3 sequence. For this analysis, all athletes with a history of cardiovascular disease or pathological late gadolinium enhancement were excluded. Athletes were classified according to the Mitchell Sports Classification based on the intensity (low (L) / moderate (M) / high (H)) of the dynamic (D) and static components (S). Native- and post-contrast T1 mapping times were calculated by manually tracing the endocardial- and epicardial contours.
Results:
A total of 117 elite athletes (44% women; mean age 26±6.5; Mitchell sports classification: 47 HS/HD, 8 HS/LD, 5 HS/MD, 36 LS/HD, 16 MS/HD, 3 MS/MD, 3 missing) and 48 healthy non-athletic controls (54% women; mean age 39±15.1). Men had lower t1 times compared to women, both in athletes (949ms vs 964ms, $p<0.05$) and controls (969ms vs 1000ms, $p<0.05$). Moreover, elite athletes had a lower global native T1 time compared to healthy non-athletic controls (955 vs 983, $p<0.05$). There were significant differences in native T1 time between the Mitchel Sport classifications (Kruskal-Wallis $p<0.05$); left ventricular mass (LVM) ($R=-0.47$, $p<0.05$) and LVM divided by left ventricular end-diastolic volume ($R=-0.4$, $p<0.05$) were both negatively correlated with native T1 mapping time.
Conclusion:
Conclusion: Men demonstrate markedly shorter T1 times compared to women in both athletes and controls. Moreover, native T1 times were associated with markers for cardiac remodelling. Sex- and athlete-specific characteristics should be taken into account when

interpreting T1 times in athletes.

Keywords:
Elite athlete, Native T1 mapping, CMR

Figure:
Differences in native T1 inversion recovery times between elite athletes and healthy non-athletic controls according to the American Heart Association 16-segmented model.