­Table 1. Associates of vascular calcification

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Author | Country | Time | CKD stages | sample | Findings | Data | Calcification | Ref |
| Ahmed *et al.* | United States | 2001 | 5D | 20 | Female more prevalent | Cases vs. control: 90% vs. 49.7% | Calciphylaxis (calcific uremic arteriolopathy) | (1) |
| Alayoud *et al* | France | 2020 | 5D (HD) | 28 | Male progress more | Male in progression vs. no progression: 36.4% (8M/14F) vs. 83.3% (5M/1F), p = 0.02 | Progression of CAC (Agatston score) measured with multi-slice ultra-fast CT | (2) |
| Al-Rifai *et al.* | Lebanon | 2011 | 5D (HD) | 43 | Neutral | No association between VC and gender | Hand X-rays | (3) |
| Arjona Barrionuevo *et al.* | Spain | 2010 | 5T (awaiting transplant) | 356 | Female at risk | A positive correlation was observed between valve calcifications and female sex | Valvular calcification assessed with transthoracic echocardiography | (4) |
| Asci *et al.* | Turkey | 2010 | 5D (HD) | 207 | Male more severe | Male in patients with CACS 1–100 vs. 101–400 vs. >400: 38% vs. 72% vs. 61%, p = 0.005 | CACS calculated by summing the calcification score in the left main coronary artery, left anterior descending artery, left circumflex and right coronary artery on multislice CT. | (5) |
| Avramovski et al. | Macedonia | 2019 | 5D | 112 | Neutral | R = 0.127, p = 0.182 | AAC on lateral lumbar radiography in standing position | (6) |
| Bae *et al.* | Korea (multicenter) | 2016 | 5D (HD) | 423 | Male more severe | Median CAC score in male: 44.10 (0.00–258.70) vs. 5.15 (0.00–154.05) | CACS measured with L-spine  Radiography (Kauppila score) | (7) |
| Ballotta *et al.* | Italy | 2004 | 5D | 143 | Neutral | Male gender in patients with severe calcification vs. no calcification: 78% vs. 74%, p = 0.59 | Potential outflow artery chosen for the distal anastomosis classified during surgery as normal or as having mild-to-moderate uncalcified plaque, mild-to moderate calcification, or severe calcification | (8) |
| Bellasi *et al.* | United States | 2012 | 5D (HD) | 141 | Neutral | Women in cardiovascular calcification index 0–2 vs. 3–4 vs. 5–7 vs. 8–11: 51% vs. 48% vs. 61% vs. 38%, p = 0.57 | Cardiovascular calcification index assessed with two-dimensional echocardiography | (9) |
| Bundy *et al.* | United States (CRIC) | 2019 | 2-4 | 3404 | Neutral | Female in patients with quartiles 4 vs. 3 vs. 2 vs. 1 T50: 41% vs. 44% vs. 48% vs. 47%, ANOVA was not performed | T50 as the propensity of vascular calcification | (10) |
| Chandra *et al.* | India | 2020 | 5D | 90 | Neutral | Present vs. absent, male 67.5% vs. 62%, p = 0.59 | CAC or TAC assessed with computed tomography (Agatston score) | (11) |
| Chang *et al* | South Korea | 2012 | 5D (HD) | 289 | Neutral | Severe vs. modest calcification, male 41.8% vs. 44.7%, *p* = 0.066 | Lumbar spine lateral radiography | (12) |
| Chao *et al.* | Taiwan | 2020 | 1-5? (ESRD and CKD) | 96 | Neutral | Male in patients without vs. with AoAC: 43% vs. 47%, p = 0.711 | AoAC measured with semi-quantitation on PA chest radiography | (13) |
| Chao *et al.* | Taiwan | 2017 | 5 | 88 | Neutral | Male in patients without vs. with AoAC 53) 51 (49) 0.65 | AoAC on radiography | (14) |
| Charitaki *et al.* | United Kindom | 2014 | 5D (HD) | 303 | Male at risk | Female Pearson r = -0.124, p = 0.031 | PWV | (15) |
| Chen *et al* | Sweden | 2017 | 5D, 5T | 240 | Neutral | Score > 100 vs. ≤ 100, male 68% vs. 57%, *p* = 0.052 | Coronary artery calcification (Agatston score) | (16) |
| Chen *et al.* | United States | 2017 | 1-4 | 1541 | Male more severe | Male in CAC score 0 vs. 0-100 vs. >100: 41.7% vs. 54.3% vs. 65.2%, p < 0.001 | CACS (Agatston score) measured with electron-beam or  multidetector CT | (17) |
| Chiu *et al* | United States | 2010 | Proteinuric (1-5) | 225 | Neutral | Group 4 (severe) vs. 3 vs. 2 vs. 1, male 61% vs. 64% vs. 47% vs. 45%, *p* = 0.09 | Coronary artery calcification (Agatston score) | (18) |
| Choi *et al.* | Korea | 2019 | 5D (HD) | 97 | Male progresses more | AAC progression (+) vs. (-), male 50.9% vs. 29.5%, p = 0.033 | Lateral lumbar radiography (Kauppila score) | (19) |
| Chue *et al.* | United Kingdom | 2012 | 3 | 120 | Male common | Male vs. Female, 67% vs. 43%, *p* = 0.01 | Lumbar spine lateral radiography | (20) |
| Claes KJ | Belgium | 2013 | 5T | 115 | Neutral | Male gender percentage in patients with below median vs. above median calcification: 59% vs. 62%, p = 0.5366 | AC assessed with lumbar X-ray | (21) |
| Claes KJ |  |  |  |  |  | With vs. without, male 72% vs. 55.4%, *p* = 0.16 | Lumbar spine lateral radiography |  |
| Coen *et al.* | Italy | 2006 | 5D (HD) | 132 | Male more prevalent | Log transform of cardiac score (score log) was correlated to age (p < 0.0001), serum calcium (p < 0.005), sex (p < 0.05), with prevalence of male sex, and inversely to serum cholesterol (p < 0.05) and HDL cholesterol (p < 0.01). | Cardiac calcification assessed with multislice CT (Agatston score) | (22) |
| Coll *et al.* | Spain | 2010 | 5D | 232 | Male more prevalent with calcification | With vs. without linear calcification: 65% vs 41% | Linear calcification assessed with carotid, femoral, or brachial ultrasound | (23) |
| Craver *et al* | Spain | 2013 | 3-4 | 178 | Male more severe | Lumbar Kauppila score >5 vs. 1-5 vs. 0, male 83% vs. 80% vs. 70%, *p* = 0.017 | Lumbar spine lateral radiography | (24) |
| Davis *et al.* | United States | 2016 | 5T | 131 | Neutral | Regression coefficient estimate of Length score of three readers: 0.051, p = 0.81; -0.070, p = 0.74; -0.16, p = 0.44  Circumference score in three readers: 0.060, p = 0.78; 0.012, p = 0.96; -0.089, p = 0.66  Morphology score in three readers: 0.12, p = 0.46; 0.029, p = 0.86; 0.047, p = 0.71 | Semiquantitative calcification scoring assessed with CT of bilateral common and external iliac arteries | (25) |
| DeLoach *et al.* | United States | 2009 | 5T | 112 | Neutral | Calcification vs. no calcification: 68.4% vs. 58.1%, p = 0.29 | Aortic calcification measured with electron beam computed tomography (Agatston score) | (26) |
| Di Iorio *et al.* | Italy | 2006 | 4-5, 5D | 44 | Male more severe | Male in patients with TC score <400 vs. > 400: 42% vs. 75%, p = 0.05 | Calcification if an area  > 1 mm2 displayed a density > 400 Hounsfield units (HU) on MSCT | (27) |
| Disthabanchong *et al.* | Thailand | 2018 | 2-5D, 5T | 419 | Female more severe (subgroup) | AAC score > 6 vs. ≤ 6 in CKD stage 2 -5, male 44.4% vs. 62.6, p < 0.05  In male with stage 5D, 50% vs. 50.5% (P > 0.05)  In male with stage 5T, 67.9% vs. 58.5% (p > 0.05) | Lumbar spine lateral radiography | (28) |
| El Amrani *et al.* | Morocco | 2015 | 5D (HD) | 49 | More male with CAC | Male in group with vs. without CAC: 64.7% vs. 26,6 %, p = 0.014 | CACS assessed with CT (Agatston score) | (29) |
| El Amrani *et al.* |  |  |  |  | Neutral | Male in group with vs. without valvular calcification: 45.8% vs. 60%, p = 0.321 | Valvular calcification assessed with echocardiography with hyperechoic lesion >1 mm thick was detected on the mitral or aortic valves |  |
| Etta *et al.* | India | 2017 | 4-5 | 95 | Neutral | Male in absent vs. present of calcification: 67.6% vs. 85.7%, p = 0.08 | Cardiac valvular calcification assessed with echocardiography | (30) |
| Etta *et al.* |  |  |  |  |  | Male in absent vs. present of calcification: 71.8% vs. 70.0%, p = 0.58 | Abdominal aorta calcification assessed with lateral abdominal radiograph |  |
| Fabbian *et al.* | Italy | 2005 | 5D (HD) | 132 | Neutral | On the contrary, sex, diabetes frequency, smoking habit, history of hypertension and hyperphosphatemia, cerebrovascular and ischemic heart disease (IHD), blood pressure (BP) and antihypertensive therapy, lipids, albumin, degree of anemia, calcium, phosphate and their product were no different between the two groups. | AoAC assessed with standard PA chest radiographs | (31) |
| Fayed *et al.* | Egypt | 2019 | 5 | 172 | Neutral | Male/Female in patients with intima vs. media vs. no calcification: 11/18 vs. 37/20 vs. 50/36, ANOVA was not performed | Arterial wall calcification through intraoperative arterial biopsy obtained during creation of arteriovenous vascular access for hemodialysis. | (32) |
| Gunen Yilmaz *et al.* | Turkey | 2019 | 5D (HD) | 60 | Neutral | Female in patients with positive vs. negative CAC: 54.7% vs. 58.4%, p = 0.22 | CAC defined in panoramic radiography as heterogeneous nodular opacities in the soft tissue in the C3–C4 intervertebral area | (33) |
| Harada *et al* | Brazil | 2014 | 2-5 | 117 | Male more severe | Score >0 vs. score =0, male 78.7% vs. 42.9%, *p* < 0.001 | Coronary artery calcification (Agatston score) | (34) |
| He *et al.* | China | 2018 | 5D (HD) | 150 | Neutral | Male percentage in patients with vascular calcification vs. no calcification: 61.1% vs. 76.2%, p = 0.099 | AAC assessed with lateral lumbar radiography (Kauppila score) | (35) |
| He *et al.* | United States | 2012 | 2-4 | 2018 | Male more severe | Score >100 vs. 0-100 vs. 0, male 63.6% vs. 53.3% vs. 41.9%, *p* < 0.0001 | Coronary artery calcification (Agatston score) | (36) |
| Hou *et al* | Taiwan | 2019 | 5D (HD) | 120 | Neutral | High vs. low, male 52.8% vs. 47.8%, *p* = 0.851 | Pulse wave velocity | (37) |
| Humoud *et al.* | Kuwait | 2005 | 5D | 129 | Neutral | Male percentage in patients with vascular calcification vs. no calcification: 58.8% vs. 45.3%, p = 0.175 | Plain x-ray of the hands, including radial, palmar arterial arch, or palmar digital arteries | (38) |
| Jankovic *et al* | Serbia | 2017 | 5D (HD) | 90 | Male common | With vs. without calcification, male 66.1% vs. 35.3%, *p* = 0.008 | Forearm AVF plain radiography | (39) |
| Jansson *et al* | Sweden | 2019 | 3-4 | 84 | Neutral | With vs. without AAC, male 79% vs. 67%, *p* = 0.351 | Abdominal aortic calcification on computed tomography | (40) |
| Jean *et al* | France | 2016 | 5D (HD) | 227 | Neutral | Group 3 (severe) vs. 2 vs. 1, male 59.7% vs. 55.6% vs. 59.2%, *p* > 0.05 | Lumbar spine lateral radiography | (41) |
| Jean *et al* | France | 2009 | 5D (HD) | 161 | Male more severe | High VC score (3) vs. no VC (score 0), male 77% vs. 45%, *p* < 0.05 | Multi-site plain radiography involving pelvis, lumbar, knee, right hand, right arm, chest, skull, and orthopantomogram | (42) |
| Jean *et al.* | France | 2012 | 5D (HD) | 85 | Neutral | Progressors vs. non-progressors, female 44% vs. 52% | VC measured with semiquantitative score on plain radiological films (front pelvis, profile lumbar and knee, right hand and arm, chest, skull, and orthopantomogram) | (43) |
| Jiménez Villodres *et al.* | Spain | 2018 | 3 | 139 | Male more severe (AACS) | Pathological vs. normal AACS, male 80% vs. 63%, p < 0.05  Abnormal vs. normal KI, male 69% vs. 72%, p > 0.05 | AACS on lateral abdominal X-ray (Agatston score) and KI a low-grade CT of the abdomen | (44) |
| Kahn *et al* | Austria | 2017 | 5T | 205 | Male more severe, segment-specific | Aorta: male vs. female, 2.0 vs. 1.5, *p* = 0.511  Right common iliac artery: male vs. female, 1.0 vs. 1.0, *p* = 0.139  Total iliac artery: male vs. female, 1.00 vs. 0.50, *p* = 0.003  External iliac artery: male vs. female, 1.0 vs. 0.0, *p* <0.001 | Pelvic computed tomography | (45) |
| Kanbay *et al.* | Turkey | 2011 | 2-3 | 88 | Male gender | In univariate analysis, the Gensini CAD  severity score correlated significantly with **male**  **gender**, eGFR, and serum levels of 25-OH-vitamin D,  iPTH, FGF-23, fetuin A, and calcitonin (R = 0.474,  P = 0.001 for the latter). | Gensini score | (46) |
| Keyzer *et al.* | Netherlands | 2015 | 5T | 699 | Neutral | Male in tertile 1 vs. 2 vs. 3: 58% vs. 55% vs. 57% | Blood calcification propensity measured with Serum T50 | (47) |
| Kim *et al.* | Korea | 2019 | 5D | 47 | Neutral | Calcification vs. noncalcification, female 16.7% vs. 31.0%, p = 0.324 | Calcification in the  arterial media within 5 cm of the planned anastomosis area in preoperative duplex ultrasound | (48) |
| Kim *et al.* | Korea | 2011 | 5D | 184 | Neutral | AoACS progression (+) vs. (-): 47.8% vs. 44.5%, p = 0.657 | AoAC on chest radiography | (49) |
| Kimura *et al.* | Japan | 1999 | 5D (HD) | 137 | Male more severe | A comparison of the ACAI of men in their 40s (17.7 ± 10.3%, N = 8) was significantly higher than that of women in the same age group (4.0 ± 3.7%, N = 10, P < 0.01), indicating that abdominal aortic calcification develops earlier in men than women. | ACAI (aortic calcification area index) assessed with CT over the area above the bifurcation of the common iliac artery | (50) |
| Komatsu *et al* | Japan | 2014 | 5D (HD) | 301 | Female common | Grade 2+3 vs. 1 vs. no calcification, male 58.7% vs. 56.3% vs. 77.8%, *p* = 0.0009 | Aortic arch calcification on chest radiography | (51) |
| Lee e*t al* | Taiwan | 2014 | 5D (HD) | 712 | Neutral | Group 3 (severe) vs. 2 vs. 1 vs. none, male 38.1% vs. 42.2% vs. 45.7% vs. 43.8%, *p* = 0.606 | Aortic arch calcification on chest radiography | (52) |
| Lee *et al.* | Taiwan | 2019 | 5D (HD) | 61 | Male more severe | No vs. Severe vascular calcification, male 37% vs. 52%, p = 0.240 | AAC | (53) |
| Lee *et al.* | Korea | 2006 | 2-5 | 1078 | Male more prevalent | Male in patients with CAC vs. without CAC: 73.7% vs. 54.4%, p < 0.001 | CACS determined by MSCT (Agatston score) | (54) |
| Lioufas *et al.* | Multicenter (IMPROVE-CKD) | 2020 | 3b-4 | 278 | Male at risk | With vs. without AAC, male 73% vs. 55% | AAC (Agatston) | (55) |
| Liu *et al.* | China | 2016 | 5D | 41 | Neutral | Male vs. female in non-VC: 59.38% vs. 40.63%  Male vs. female in VC: 66.67% vs. 33.33%  P = 0.993 | VC, the degree of calcium salt deposition assessed with immunohistochemical analysis of radial arteries | (56) |
| Lockhart *et al.* | United States | 2004 | 5D (HD) | 32 | Neutral | Male in patients with high vs. low calcification score: 67% vs. 42%, p = 0.28 | Vascular calcifications on CT of the distal aorta, common iliac, external iliac and common  femoral arteries on a semi-quantitative 5-point scale. | (57) |
| London *et al.* | France | 2013 | 5D (HD) | 155 | Neutral | Gender ratio in CCA calcified vs. CCA non-calcified: 1.38±0.48 vs. 1.44±0.49, p > 0.05 | Common carotid artery (CCA) calcification assessed with ultrasonography | (58) |
| Maharem *et al* | Egypt | 2013 | 5, 5D, 5T | 73 | Neutral | VC presence vs. absence, male 57.9% vs. 31.6%, *p* = 0.056 | Pelvic and hand plain radiography | (59) |
| Mazzaferro *et al.* | Italy | 2007 | 5D, 5T | 100 | Male more severe | Male dialysis vs. male transplant (Tx) vs. female dialysis vs. female transplant, 1944 vs. 945 vs. 157 vs. 35, *p* < 0.02 | Coronary artery calcification (Agatston score) | (60) |
| Merjanian *et al.* | United States | 2003 | Nondialyzed DAD | 32 | Loss of CAC prevalence in male DKD vs. control | Male 92% vs. 67%, p > 0.05  Female 95% vs. 54%, p < 0.05 | CAC measured with electron beam CT (Agatston and volumetric method) | (61) |
| Merjanian *et al.* |  |  |  |  | Male prone to increased severity of CAC | Male 619 vs. 18, p < 0.05  Female 232 vs. 6, p < 0.001 | CAC measured with electron beam CT (Agatston and volumetric method) |  |
| Miyatake *et al.* | Japan | 2020 | 5T | 50 | Neutral | Male vs. female 1.72 (0.00–1.55) vs. 0.00 (0.00–1.26) | Aortic calcification area index | (62) |
| Mizuiri *et al.* | Japan | 2018 | 2-5 | 145 | Neutral | CACS quartile 1 vs. 2 vs. 3 vs. 4, male 63.9% vs. 54.1% vs. 64.9% vs. 62.9%, p > 0.05  IACS quartile 1 vs. 2 vs. 3 vs. 4, male 52.8% vs. 68.6% vs. 65.8% vs. 58.3% | CACS (Agatston score) and IACS using thoracicoabdominal multi-detector computed tomography. | (63) |
| Moorehead *et al.* | United Kindom | 1974 | 5D (HD) | 150 | Male at risk | Female sex may possibly confer some advantage with respect to erosions in the age range 20-59 years (women v. men: 2-2 % v. 12-2 %; P < 0-04). | Erosions | (64) |
| Morena *et al* | France | 2009 | 1-5 | 133 | Male common | Severe vs. minor, 73.6% vs. 36.1%, *p* < 0.0001 | Coronary artery calcification (Agatston score) | (65) |
| Munguia *et al.* | Spain | 2015 | 5T | 119 | Neutral | Without VC vs. with VC: 62.3% vs. 70%, p = 0.384 | AAC assessed with lateral lumbar radiography of L4-S1 (KauppiIa index) | (66) |
| Nigwekar *et al.* | United States | 2016 | 5D (HD) | 3090 | Female more common | Central CUA vs. peripheral CUA, female 73% vs. 61% | Calcific Uremic Arteriolopathy (CUA) | (67) |
| Nitta *et al* | Japan | 2018 | 5D (HD) | 216 | Female more severe | Group 3 (severe) vs. 2 vs. no calcification, female 47.5% vs. 40.9% vs. 23.1%, *p* < 0.0001 | Aortic arch calcification on chest radiography | (68) |
| Niu *et al.* | China | 2019 | 5D (PD) | 150 | Neutral | Male in patients with presence vs. absence of AAC: 51.65% vs. 49.15%, p = 0.765 | AAC assessed with lateral abdominal plain film, frontal pelvic radiograph and both hands radiograph over the abdominal aorta, iliac artery, femoral artery, radial artery,  and finger arteries | (69) |
| Niu *et al.* | China | 2019 | 5D | 56 | Neutral | Male in patients with progression score <100 vs. 100–500 vs. > 500: 59.3% vs. 73.7% vs. 70.7%, p = 0.572 | CAC measured with MSCT (Agatston score) | (70) |
| Oh *et al.* | Korea | 2005 | 5D (PD) | 50 | Neutral | Male in patients with vs. without calcified plaques: 64.3% vs. 83.3%, p > 0.05 | Calcified plaques measured with B-mode ultrasound observations of plaques | (71) |
| Oh *et al.* | Germany | 2002 | 5 | 39 | Female more prevalent in childhood-onset CRF aged 19-39 | Compared with healthy control subjects, median calcium scores exceeded the age-specific 95th normal percentiles on average 10-fold in male and 17-fold in female patients (Figures 2 and 3). | Coronary artery calcification burden was assessed by CT scan with ECG gating (Agatston score) | (72) |
| Okamoto *et al* | Japan | 2018 | 5D (HD) | 184 | Male more likely to worsen | Annual progression rapid vs. slow, male 53% vs. 27%, *p* = 0.008 | Abdominal aorta calcification on computed tomography | (73) |
| Ossareh *et al.* | Iran | 2020 | 5D (HD) | 143 | Male more severe | Male vs. female 0.76 vs. 0.69, P < .05 | Common carotid intima media thickness (ccIMT) | (74) |
| Petrovic *et al.* | Serbia | 2020 | 5D (HD) | 80 | Neutral | Male in patients with PWV ≤ 8.8 m/s vs. > 8.8 m/s: 14% vs. 20%, p = 0.119 | PWV | (75) |
| Qureshi *et al* | Sweden | 2015 | 5T | 89 | Male more severe | Moderate-severe vs. non-minimal, male 76% vs. 54%, *p* = 0.04 | Biopsy-verified calcification in epigastric arteries | (76) |
| Raggi *et al.* | United States | 2011 | 5D (HD) | 144 | Neutral | Female gender in patients with 1 vs. 2 vs. 3 calcified valves: 54.1 vs. 55.3 vs. 38.9, p = 0.19 | Valvular calcification assessed with electron-beam CT | (77) |
| Renaud *et al.* | France | 1988 | 5D (HD) | 24 | Male increase more rapid | Correlation coefficient for male vs. annual calcification increase = 1.97, *p* < 0.01 | Lumbosacral radiography for linear calcifications involving the abdominal aorta, iliac and femoral arteries | (78) |
| Ribeiro *et al.* | Portugal | 1998 | 5D (HD) | 92 | Neutral | 58.5% vs. 56.7%, p > 0.05 | Mitral valve calcification determined in B-mode echocardiograph | (79) |
| Ribeiro *et al.* |  |  |  |  |  | 62.5% vs. 52.3%, p > 0.05 | Aortic valve calcification determined in B-mode echocardiograph |  |
| Roca-Tey *et al.* | Spain | 2009 | 5D (HD) | 45 | Neutral | Male in patients with vs. without AVF calcification: 81.5% vs. 55.6%, p = 0.09 | Radial or brachial AVF calcification on spiral CT | (80) |
| Schlieper *et al* | Serbia | 2008 | 5D (HD) | 212 | Male common | With vs. without, male 78% vs. 47%, *p* < 0.0001 | Vascular access calcification on plain radiography | (81) |
| Shu *et al* | Taiwan | 2012 | 5T | 99 | Male more severe | Group 5 (severe) vs. 4 vs. 3 vs. 2 vs. 1, male 66.7% vs. 53.3% vs. 63.6% vs. 65.0 vs. 29.3%, *p* = 0.027 | Coronary artery calcification (Agatston score) | (82) |
| Sigrist *et al.* | United Kingdom | 2006 | 4-5D | 134 | Male common | Calcification tertiles 3rd vs. 2nd vs. 1st, male 81% vs. 71% vs. 46%, *p* < 0.001 | Superficial femoral artery in computed tomography | (83) |
| Ștefan *et al* | Romania | 2019 | 2-4 | 44 | Neutral | Male in RRI > 0.7 vs. RRI ≤ 0.7: 65% vs. 52%, p = 0.4 | Intrarenal resistance index (RRI) obtained from Doppler ultrasonography of interlobar  and arcuate arteries in the upper, middle, and lower  parts of the kidney. | (84) |
| Strózecki *et al.* | Poland | 2005 | 5D (HD) | 65 | Neutral | 48.5% vs. 43.7%, p > 0.05 | Echocardiographic  criteria of dense echoes in mitral vascular calcification  (MVC) or aortal vascular calcification (AVC) valve  leaflets or annulus. | (85) |
| Tangvoraphonkchai *et al.* | United States | 2019 | 5D (PD) | 24 | Male gender (%) | Stable PWV vs. increased PWV, male 33% vs. 75% | Pulse wave velocity as surrogate | (86) |
| Tomiyama *et al.* | Brazil | 2010 | 2-4 | 50 | Male more prevalent | Male in patients without vs. with calcification: 47% vs. 79%, p = 0.02 | CACS using MSCT (Agatston score) | (87) |
| Turan *et al* | Turkey | 2016 | 5D (HD) | 224 | Male more severe | Group 4 (severe) vs. 3. vs. 2 vs. no calcification, male 56% vs. 59% vs. 38% vs. 41%, *p* = 0.003 | Coronary artery calcification (Agatston score) | (88) |
| Wang *et al.* | China (Hong Kong) | 2014 | 3-5 | 300 | Male more severe | Male in CACS 0 vs. 1–99 vs. 100–399 vs. ≥400: 57.5% vs. 56.9% vs. 77.3%, p <0.001 | CACS (Agatston score) measured with CT | (89) |
| Wang *et al.* | Hong Kong | 2003 | 5D (PD) | 192 | Neutral | Male in patients with vs. without valvular calcification: 50.0% vs. 51.5%, p = 0.842 | Valvular calcification on ultrasound of the aortic valve or mitral valve or mitral annulus | (90) |
| Wu *et al.* | Taiwan | 2017 | 5D (PD) | 190 | Neutral | Grade 0 vs. 1 vs. 2 vs. 3: 43.8% vs. 40.4% vs. 58.3% vs. 37.0%, p = 0.293 | AoAC detected with chest X-ray | (91) |
| Yoshikawa *et al.* | Japan | 2013 | 5D (HD) | 134 | Male at risk | β = -0.20, p = 0.008 | Abdominal aortic calcium volume score (AACVS) | (92) |
| Zhou *et al.* | Sweden | 2018 | 1-5 | 151 | More male had AAC | Male vs. female: 76% vs. 69% | AAC evaluated with lateral lumbar X-ray (Kauppila score) | (93) |
| Zhou *et al.* |  |  |  |  |  | More men (76%) had AAC than women (69%). 沒有p-value |  |  |

Table 2. Causes of vascular calcification

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Author | Country | Time | CKD stages | sample | Findings | Data | Calcification | Ref |
| Abd Alamir *et al.* | United States | 2015 | 2-3 | 2070 | Neutral | OR 1.21 (0.94–1.56) | Mitral annular calcification (MAC) assessed with coronary calcium scanning (Agatston score) | (94) |
| Adragao *et al.* | Portugal | 2004 | 5D (HD) | 123 | Male at risk | Vascular calcification score ≥ 3: OR 7.47 (2.9–19.1) | Simple vascular calcification score based on plain  radiographic films of pelvis and hands (Adragao) | (95) |
| Adragao *et al.* |  |  |  |  |  | Iliac score > 0: OR 3.5 (1.5–8.3) |  |  |
| Baralić *et al.* | Serbia | 2018 | 5D (HD) | 56 | Male at risk? (male = 0?, female = 1?) | B = -12.740, 95% CI = -23.967– -1.513, β = -0.273 | Index of left ventricular mass (iLVM) | (96) |
| Baralić *et al.* |  |  |  |  |  | B = -47.88, 95% CI = -95.3– -0.464, β = -0.296 | Relative wall thickness (RWT) |  |
| Bellasi *et al* | United States | 2008 | 5D | 142 | Male more severe (subgroup) | For coronary artery, male β = 735.82, p = 0.0366  For thoracic aorta, gender *p* > 0.05 | Coronary artery calcification (Agatston score) and thoracic aorta calcification | (97) |
| Blacher *et al.* | France | 1998 | 5D (HD) | 74 | Male at risk (male = 1, female = 2) | β = -0.25, p = 0.0074 | LV mass calculated according to the Penn convention | (98) |
| Budoff *et al.* | United States (CRIC) | 2011 | 2-3A | 1908 | Male at risk | Women as independent variable for overall CAC: OR 0.43 (0.35-0.53) | CAC detected using CT (Agatston score) | (99) |
| Budoff *et al.* |  |  |  |  |  | Women as independent variable for CAC in patients without CVD: 0.36 (0.28-0.45) |  |  |
| Budoff *et al.* |  |  |  |  |  | Women as independent variable for CAC in patients with CVD: 0.67 (0.45-1.00) |  |  |
| Bundy *et al* | United States | 2019 | 2-4 | 1274 | Neutral | Female sex in Quartiles 4 vs. 3 vs. 2 vs. 1 of T50: 46% vs. 45% vs. 49% vs. 47% | Serum calcification propensity quantified as transformation time | (100) |
| Cai *et al.* | China | 2015 | 5D (HD) | 129 | Neutral | Abdominal aorta severe calcification, male OR 0.549 (0.113–2.661), p = 0.456 | AAC assessed with lateral plain radiograph | (101) |
| Chae *et al.* | Korea | 2018 | 1-5 | 1832 | Female milder | Female in quartile 1 vs. 2 vs. 3 vs. 4: 44.3% vs. 41.3% vs. 37.0% vs. 38.1%, p = 0.101, p for trend = 0.025 | Brachial ankle PWV (baPWV) | (102) |
| Chae *et al.* |  |  |  |  |  | P = 0.101但是p for trend = 0.025 |  |  |
| Chen *et al.* | Sweden | 2017 | 5D, 5T | 240 | Male at risk | β = 0.35, *p* = 0.008 | Coronary artery calcification (Agatston score) | (16) |
| Chiu *et al.* | United States | 2010 | Proteinuric (1-5) | 225 | Male at risk | Male with significantly higher probability of more severe VC (*p* = 0.01) | Coronary artery calcification (Agatston score) | (18) |
| Chue *et al* | United Kingdom | 2012 | 3 | 120 | Male at risk | Female β = -0.34 (-13.45– -4.48) | Lumbar spine lateral radiography | (20) |
| Claes *et al.* | Belgium | 2013 | 5T | 115 | Male gender (%) | PWV ≤ 7.35 m/s vs. > 7.35 m/s: 74 vs. 56, p = 0.05 | PWV | (21) |
| Coll *et al.* | Spain | 2010 | 5D | 232 | Neutral | OR 1.57 (0.69–3.55), p = 0.27 | Linear calcification assessed with carotid, femoral, or brachial ultrasound | (23) |
| Craver *et al.* | Spain | 2013 | 3-4 | 178 | Male at risk | For AAC severity, male β = 1.237 (0.058-2.417), *p* = 0.04  For severe AAC, in all patients, male OR 4.218 (1.403-14.207), p = 0.014  For severe AAC, in eGFR < 30: OR 4.167 (1.050-20.178) | Abdominal aortic calcification (AAC) (Kauppila Index) | (24) |
| Dai *et al* | Sweden | 2020 | 5 | 152 | Male at risk | Male OR 6.67 (2.53–17.58) | coronary artery  calcification (CAC) score by computed tomography (CT) | (103) |
| Evenpoel *et al.* | Belgium | 2015 | 5T | 268 | Male at risk | For coronary calcification, female β = -0.64, *p* < 0.0001  For thoracic aortic calcification, female β = -0.32, *p* = 0.008 | Coronary artery calcification (Agatston score) and thoracic aortic calcification | (104) |
| Evenpoel *et al.* | Belgium | 2015 | 5T | 268 | Male at risk | β = -0.45, t = 4.01, p = 0.0001 | Annualized CACS change | (104) |
| Fain et al. | United States | 2018 | 5D (HD) | 37 | Male at risk | Β ± SE = 2.23 ± 0.78, R2 = 0.090 | Carotid-femoral PWV | (105) |
| Fain et al. |  |  |  |  |  | B ± SE = 4.16 ± 1.65, R2 = 0.121 | brachial artery flow-mediated dilation (FMD) |  |
| Fayed *et al.* | Egypt | 2019 | 5D (HD) | 81 | Neutral | β = 0.022, p = 0.695 | AAC measured with spiral CT of the last 10 cuts of the abdominal aorta before its division into the two common iliac arteries | (106) |
| Filgueira *et al.* | Brazil | 2011 | 2-4 | 72 | Neutral | Female as a factor: Coefficient = 0.149, SEM = 0.663, p = 0.82 | CACS (Agatston score) measured with computed tomography | (107) |
| Floege *et al.* | Multicenter | 2010 | 5D (HD) | 360 | Male at risk | Parameter estimate = 0.42599, SE = 0.42599, p = 0.0011 | CAC | (108) |
| Floege *et al.* |  |  |  |  |  | Using multivariate analysis, factors shown to predict  CAC in the current study included older age, male gender,  longer dialysis vintage and diabetes, results consistent with  those reported previously. |  |  |
| Fusaro *et al.* | Italy | 2015 | 5D (HD) | 314 | Neutral | OR 1.52 (0.87–2.66), p = 0.1 | Vascular calcification assessed with radiograph of the thoracic and lumbar  regions of the spinal column in the latero-lateral view according to Witteman et al (109). | (110) |
| Fusaro *et al.* | Italy | 2014 | 5D (HD) | 387 | Male gender | OR 1.86 (CI 1.20–2.91) | Spine deformity index (SDI) > 1 | (111) |
| Gelev *et al.* | Macedonia | 2008 | 5D (HD) | 150 | Male common | VC prevalence: male vs. female, 87.9% vs. 61.0%, *p* < 0.03  Intimal VC prevalence: male vs. female, 53.8% vs. 32.2%, *p* < 0.02  Medial VC prevalence: male vs. female, 34.1% vs. 28.8%, *p* > 0.05 | Pelvic antero-posterior radiography | (112) |
| Golembiewska *et al.* | Sweden | 2020 | 5, 5D | 149 | Male at risk | Male OR 4.4 (1.6–11.1), *p* = 0.003 | Inferior epigastric artery histopathology calcification grading | (113) |
| Golembiewska *et al.* |  |  |  |  |  | Male -x-> copeptin: β = −0.08 (0.31) |  |  |
| González-Parra E *et al.* | Spain | 2015 | 1-5? | 704 | Male gender | r = −0.084, 95% CI -0.155– -0.012, p = 0.0215 | Parathormone levels | (114) |
| González-Parra E *et al.* |  |  | 不確定是不是CKD cohort |  |  | r = −0.191, 95% CI -0.301– -0.080, p = 0.0007 | FGF-23 |  |
| Gross *et al.* | German | 2006 | 3-5, 5D | 23 | Neutral | Media thickness β = 0.068, 95% CI 0.009 to 0.071, p = 0.666  Intima thickness β = 0.041, 95% CI 0.303 to 0.233, p = 0.792  Media area β = 0.084, 95% CI 0.609 to 0.346, p = 0.581  Intima area β = 0.1, 95% CI 0.609 to 0.346, p = 0.524  Plaque area β = 0.075, 95% CI 0.216 to 0.37, p = 0.598  Lumen area β = 0.035, 95% CI 1.437 to 1.827, p = 0.811  Lumen area/lumen + intima β = 0.055, 95% CI 0.077 to 0.111, p = 0.715  CRP intima β = 0.019, 95% CI 0.299 to 0.265, p = 0.904  CRP media β = 0.127, 95% CI 0.275 to 0.108, p = 0.385  PTX3 intima β = 0.417, 95% CI 0.441 to -0.085, p = 0.005  PTX3 media β = 0.0, 95% CI 0.175 to 0.175, p = 1  Fetuin A intima β = 0.122, 95% CI 0.691 to 0.291, p = 0.416  Fetuin A media β = 0.171, 95% CI 0.770 to 0.203, p = 0.246  HIF-1 intima β = 0.091, 95% CI 0.411 to 0.218, p = 0.541  HIF-1 media β = 0.035, 95% CI 0.23 to 0.291, p = 0.814  C5b-9 intima β = 0.004, 95% CI 0.605 to 0.622, p = 0.978  C5b-9 media β = 0.09, 95% CI 0.31 to 0.558, p = 0.567  Collagen IV intima β = 0.195, 95% CI 0.36 to 0.081, p = 0.208  Collagen IV media β = 0.044, 95% CI 0.221 to 0.167, p = 0.78  TGF-β intima β = 0.007, 95% CI 0.215 to 0.225, p = 0.963  TGF-β media β = 0.011, 95% CI 0.25 to 0.233, p = 0.943  ET-1 intima β = 0.033, 95% CI 0.254 to 0.204, p = 0.829  ET-1 media β = 0.012, 95% CI 0.265 to 0.286, p = 0.937  vWF intima β = 0.051, 95% CI 0.367 to 0.52, p = 0.729  vWF media β = 0.034, 95% CI 0.492 to 0.392, p = 0.822  eNOS intima β = 0.039, 95% CI 0.136 to 0.104, p = 0.789  eNOS media β = 0.09, 95% CI 0.193 to 0.105, p = 0.556  Glycophorin A intima β = 0.083, 95% CI 1.852 to 1.054, p = 0.582  CD68 intima β = 0.148, 95% CI 0.909 to 2.518, p = 0.349  CD68 media β = 0.046, 95% CI 7.923 to 5.835, p = 0.761  Intima calcium β = 0.033, 95% CI 5.526 to 6.727, p = 0.844  Intima phosphorus β = 0.057, 95% CI 2.774 to 3.918, p = 0.731  Media calcium β = 0.215, 95% CI 9.173 to 1.793, p = 0.181  Media phosphorus β = 0.118, 95% CI 2.185 to 1.046, p = 0.479  CRP in situ hybridization intima β = 0.184, 95% CI 0.246 to 1.049, p = 0.216  CRP in situ hybridization media β = 0.072, 95% CI 0.246 to 1.049, p = 0.630 | Coronary calcification parameters | (115) |
| Gruppen *et al.* | Dutch | 2003 | 5D | 140 | Male gender at risk | β = 0.21, p = 0.009 | LVMI | (116) |
| Gruppen *et al.* |  |  |  |  | Neutral | β = 0.17, p = 0.05 | Aortic valve calcification |  |
| Harada *et al.* | Brazil | 2014 | 2-5 | 117 | Male at risk | Male OR 4.92 (2.07–11.70), *p* < 0.01 | Coronary artery calcification (Agatston score) | (34) |
| Ho et al. | Taiwan | 2019 | 5D | 61 | Male gender (female = 0, male = 1) | B = 1688.01, SE = 681.54,t = 2.48, p = 0.02 | CAC (Agatston) | (117) |
| Hou *et al.* | Taiwan | 2019 | 5D (HD) | 120 | Female gender | OPG tertile 1/2/3: 62.5% / 55.0% / 32.%, p = 0.008\* | OPG | (118) |
| Hou *et al.* |  |  |  |  |  | Bone loss -> OPG -> calcification |  |  |
| Ishimura *et al.* | Japan | 2004 | 5D (HD) | 594 | Male at risk | OR 2.339 (1.466–3.732), p = 0.0004 | Aortic calcification | (119) |
| Ishimura *et al.* |  |  |  |  |  | OR 1.857 (1.043–3.306), p = 0.0355 | Hand arteries calcification |  |
| Ishimura *et al.* | Japan | 2002 | 5D (HD) | 421 | Male at risk (subgroup) | In diabetics, male OR 3.38 (1.289-8.860), *p* = 0.0019  In non-diabetics, male OR 1.328 (0.252-6.997), *p* = 0.7376 | Digital artery on hand radiography | (120) |
| Jankovic *et al.* | Serbia | 2017 | 5D (HD) | 90 | Male at risk and more severe | For VC risk, female OR 0.134 (0.04–0.45), *p* = 0.001  For VC severity relation, female β = –0.432 (-4.41– -1.86), *p* < 0.001 | Forearm AVF plain radiography | (39) |
| Jankovic *et al.* | Serbia | 2015 | 5D (HD) | 90 | Male gender | β = -0.432, p < 0.001 | overall calcification  score | (121) |
| Jansson *et al.* | Sweden | 2019 | 3-4 | 84 | Neutral but  male more severe | Among total cohort, male not associated with AAC  Among those with AAC, male β = 0.413, *p* = 0.03 | Abdominal aortic calcification on computed tomography | (40) |
| Jean *et al* | France | 2009 | 5D (HD) | 161 | Neutral | Female OR 0.79 (0.3 – 1.8), *p* = 0.5 | Multi-site plain radiography involving pelvis, lumbar, knee, right hand, right arm, chest, skull, and orthopantomogram | (42) |
| Jean *et al.* | France | 2016 | 5D (HD) | 227 | Female gender | OR 0.16 (0.075−0.362) | Serum sclerostin level | (41) |
| Jean *et al.* | France | 2012 | 5D (HD) | 85 | Neutral | Progressors, female OR 0.51 (0.185–1.426), p = 0.2 | VC measured with semiquantitative score on plain radiological films (front pelvis, profile lumbar and knee, right hand and arm, chest, skull, and orthopantomogram) | (43) |
| Jean *et al.* | France | 2008 | 5D (HD) | 253 | Female gender | Vitamin D (25D) deficient vs. sufficient: 53% vs. 28%, p < 0.05 | Vitamin D (25D) deficiency | (122) |
| Jean *et al.* |  |  |  |  |  | Vitamin D deficiency was reported to be  associated with cardiovascular calcification, 5 |  |  |
| Jung *et al.* | South Korea | 2006 | 5D (HD) | 40 | Male deteriorate rapidly | For calcification progression at 5-yr, male β = 1.365, *p* = 0.04 | Coronary artery calcification (Agatston score) | (123) |
| Kanbay *et al.* | Turkey | 2010 | 2-3 | 177 | Male gender | R = -0.181, p = 0.016 | Gensini score | (124) |
| Kanbay *et al.* |  |  |  |  |  | The Gensini score values significantly correlated in univariate analysis with gender (R = -0.181, P = 0.016), presence of hyperension (R = 0.203, P = 0.007), HDL cholesterol level (R = -0.158, P = 0.047), eGFR (R = -0.315, P 0.001), iPTH (R = 0.152; P = 0.044), FGF 23 (R = 0.868; P = 0.001), and fetuin A levels (R = 0.491; P = 0.001) but not with the vitamin D values. |  |  |
| Kestenbaum *et al.* | United States (MESA study) | 2009 | 3-5 | 562 | Male gender at risk | IRR 2.27 (1.26–4.09) | CACS measured with electron beam CT or  multidetector row helical CT | (125) |
| Kestenbaum *et al.* |  |  |  |  | Neutral | IRR 1.10 (0.84–1.42), p = 0.50 | Progression of CAC |  |
| Komatsu *et al.* | Japan | 2014 | 5D (HD) | 301 | Male gender (%) | Grade 0 vs. 1 vs. 2+3: 98/126 vs. 63/112 vs. 37/63, p = 0.0009 | AoAC | (51) |
| Maharem *et al.* | Egypt | 2013 | 5-5T | 73 | Male gender |  | SVCS | (59) |
| Maharem *et al.* |  |  |  |  |  | VC was significantly associated with older age, male gender, longer HD duration, lower albumin, higher LDL-c, higher carotid plaques and lower BMD at the lumbar spine and the T-score value but had no significant association with the following parameters: duration of transplantation, blood pressure, total cholesterol, TG, Ca, PO4, Ca·PO4, iPTH, CRP, fetuin A, e-GFR and IMT. Also no significant association was seen between fetuin-A gene polymorphism and VC. Patients with VC had higher CRP than those without but did not reach a significant value. (Table 10). |  |  |
| Maharem *et al.* |  |  |  |  |  | P = 0.056 不應該相關，但是內文說相關 |  |  |
| Maia *et al.* | Brazil | 2018 | 5D (HD) | 309 | Female more prevalent | Prevalence ratio 2.004 (1.012 –3.966) | CAC assessed with panoramic radiographs | (126) |
| Manghat *et al.* | United Kindom | 2011 | 1-4 | 145 | Male at risk (subgroup) | General, male β = 0.06, p =0.54  In in CKD stage 4, male β = 0.29, t =2.04, p =0.049 | Arterial Stiffness (SIDVP) | (127) |
| Maréchal *et al.* | Belgium | 2012 | 5T | 197 | Women less at risk | Annualized progression of CACS: regression coefficient = -0.09, SE = 0.04, 95%CI -0.17– -0.01, p = 0.03 | CACS (Agatston score) | (128) |
| Mazzaferro *et al.* | Italy | 2007 | 5D, 5T | 100 | Male at risk | Male OR 10.5 (3.2–34.4), *p* < 0.0001 | Coronary artery calcification (Agatston score) | (60) |
| Miyatake *et al.* | Japan | 2020 | 5T | 50 | Neutral | Female β = -0.051, p = 0.741 | Aortic calcification area index | (62) |
| Moldovan *et al.* | Romania | 2010 | 5D (HD) | 81 | Male gender at risk of progression | OR 7.226 (1.138–45.882) | Vascular calcification on hands and pelvis bone radiographs | (129) |
| Morena *et al.* | France | 2009 | 1-5 | 133 | Male more severe | Male OR 4.95 (2.36–10.37), *p* < 0.0001 | Coronary artery calcification (Agatston score) | (65) |
| Muntner *et al.* | United States | 2006 | 5D (HD) | 148 | Neutral | Prevalence rate ratio 1.37 (0.72–2.62) | CACS ≥ 100 assessed with cardiac CT | (130) |
| Nakayama *et al.* | Japan | 2013 | 5D (HD) | 47 | Sex (male:0, female:1) | β = -0.41, t = -2.688, p = 0.014 in model with ΔP | Aortic calcification area index (ACAI) | (131) |
| Nakayama *et al.* |  |  |  |  |  | β = -0.407, t = -2.608, p = 0.017 in model with ΔCa × P |  |  |
| Nemeth *et al.* | Hungary | 2015 | 5T | 993 | Gender | B = −3.968, 95%CI −6.006– −1.930, β = −0.116, p < 0.001 | Pulse pressure | (132) |
| Nishiura *et al.* | Japan | 2009 | 5D (HD) | 99 | Male gender | HR 3.034 (1.028–8.948) | OPG level | (133) |
| Nishizawa *et al.* | Japan | 2015 | 5D (HD) | 207 | Neutral | β = -0.095, p = 0.174 | CACS (Agatston score) using multidetector computed tomography | (134) |
| Nishizawa *et al.* | Japan | 2004 | 5D (HD) | 332 | Male at risk | Male OR 3.380 (1.289-8.860), *p* = 0.0019 | Digital artery on hand radiography | (135) |
| Nitta *et al.* | Japan | 2018 | 5D (HD) | 216 | Female more severe | Female β = 0.221 (0.124–0.319), p <0.0001 | Aortic arch calcification on chest radiography | (68) |
| Nitta *et al.* | Japan | 2018 | 5D (HD) | 389 | Female gender | β = 0.221, 95%CI 0.124–0.319, p < 0.0001 | AoAC | (68) |
| Okamoto *et al.* | Japan | 2018 | 5D (HD) | 184 | Male deteriorate rapidly | Male OR 3.29 (1.27–8.53), p = 0.014 | Abdominal aortic calcification index | (73) |
| Oprisiu *et al.* | France | 2002 | 5D (HD) | 24 | Male more likely to progress | Male significant correlation with calcification extension | Pelvic and lumbar lateral radiography | (136) |
| Pateinakis *et al.* | Greece | 2013 | 5D (HD) | 81 | Gender | β = -0.163, p = 0.025 | Common carotid intima-media thickness (ccIMT) | (137) |
| Pateinakis *et al.* |  |  |  |  | Neutral | β = -0.128, p = 0.15 | Pulse wave velocity |  |
| Porter *et al.* | United Kindom | 2007 | 3-4 | 112 | Male gender | OR 43.713 (2.92–654.0) | CAC | (138) |
| Qureshi *et al.* | Sweden | 2015 | 5T | 89 | Male at risk of medial VC, not CAC | For epigastric artery, male RR 1.82 (1.03–1.16), *p* = 0.03  For coronary artery, male RR 0.83 (0.38-1.81), *p* = 0.63 | Biopsy-verified calcification in epigastric arteries and coronary artery calcification (Agatston score) | (76) |
| Raggi *et al.* | United States and Europe | 2002 | 5D (HD) | 205 | Male at risk | Female β = -0.587547, p = 0.0167 | Coronary artery calcification | (139) |
| Raggi *et al.* |  |  |  |  | Neutral | Female as independent variable: parameter estimate = -0.044508, p = 0.9036 | Aortic calcification (Agatston score) |  |
| Ramalho *et al* | Brazil | 2019 | 3-4 | 356 | Neutral | B = 0.10, 95% CI = -0.15–0.35, p = 0.45 | Urinary calcium excretions (UCE) | (140) |
| Schlieper *et al* | Serbia | 2008 | 5D (HD) | 212 | Male at risk | Male OR 3.95 (1.89–8.27), *p* = 0.0001 | Vascular access calcification on plain radiography | (81) |
| Schlieper *et al.* | Serbia | 2009 | 5D (HD) | 194 | Male at risk | For composite score, male OR 2.32 (1.19–4.52), *p* = 0.014  For Adragao score, male OR 2.75 (1.41–5.38), *p* = 0.003 | Pelvic, hand, arm plain radiography and echocardiography | (141) |
| Schlieper *et al.* | Serbia | 2008 | 5D (HD) | 212 | Male gender | OR 5.08 (2.18–11.86) | Vascular access calcification | (81) |
| Scialla *et al.* | United States | 2011 | 1-5 | 351 | Female gender | Female -> Osteoprotegerin: 10.2% (0.2%– 21.3%) | OPG (percentage difference) | (142) |
| Sharma *et al.* | United Kindom | 2007 | 5 (for renal transplant evaluation) | 140 | Neutral | OR 0.45 (0.16–0.81), p = 0.53 | MAC assessed with echocardiography | (143) |
| Shu *et al.* | Taiwan | 2012 | 5T | 99 | Male more severe | Female β = -1.61, p = 0.0021 | Coronary artery calcification (Agatston score) | (82) |
| Sigrist *et al* | United Kingdom | 2007 | 4-5D | 134 | Male deteriorate rapidly | For calcification progression at 2-yr, male OR 8.82 (1.82 to 42.65), *p* = 0.007 | Superficial femoral artery calcification on computed tomography | (83) |
| Sigrist et al. | United Kingdom | 2006 | 4-5D | 134 | Male at risk | Female β = -2.108, *p* < 0.001 | Superficial femoral artery in computed tomography | (144) |
| Solbu *et al.* | Multicenter | 2016 | 5D (HD) | 2773 | Male at risk | HR 1.49 (1.21–1.83) | Atherosclerotic events including the first event of the following: non-fatal myocardial infarction, fatal coronary heart disease, non-fatal and fatal non-hemorrhagic stroke, coronary revascularization procedures and death from ischemic limb disease | (145) |
| Stavroulopoulos *et al.* | United Kindom | 2011 | 3-4 | 112 | Male at risk | OR 27.808 (1.625–475.97) | CAC on multi-slice CT scanning of the thorax measured with Agatston / Janowitz scoring system | (146) |
| Stavroulopoulos *et al.* |  |  |  |  | Neutral in CKD patients with diabetes | within the diabetes group females progressed the same as males, 9/18 females (50% of females with diabetes and CKD), the same proportion as male with diabetes (Figure 3b). This was in sharp contrast to the group without diabetes, where 11/12 of the progressors were men compared to only one female progressor |  |  |
| Sumida *et al.* | Japan | 2010 |  |  | Male gender | Male gender was identified as an independent determinant for CAP. | Coronary artery plaque (CAP) | (147) |
| Sumida *et al.* | Japan | 2010 | 5D | 135 | Neutral | Gender not associated with calcification | Carotid artery calcification on computed tomography | (147) |
| Tamei *et al.* | Japan | 2011 | 5D (HD) | 127 | Male deteriorate rapidly | For calcification progression at 5-yr, male β = 0.969, *p* = 0.0192 | Aortic arch calcification on chest radiography | (148) |
| Tanaka *et al.* | Japan | 2012 | 1-4 | 1198 | Neutral | OR 0.91, p = 0.72 | Carotid calcified plaque | (149) |
| Turan *et al.* | Turkey | 2016 | 5D (HD) | 224 | Male more severe | RR 4.14 (2.01–8.51), *p* < 0.001 | Coronary artery calcification (Agatston score) | (88) |
| Turan *et al.* | Turkey | 2013 | 5D (HD) | 191 | Male gender at risk | RR 2.79 (1.30–5.98) | CAC score assessed with calcification score measured with computed tomography of the left main, the left anterior descending, the left circumflex and the right coronary artery | (150) |
| Vipattawat *et al.* | Thailand | 2014 | 5, 5D,5T | 261 | Neutral | Among 5T patients, OR 2.49 (0.87–7.14), *p* = 0.09  Among 5 and 5D patients, OR 2.02 (0.71-5.78), *p* = 0.19 | Pelvic and lumbar spine lateral radiography  (Total vascular calcification score) | (151) |
| Wang *et al* | China | 2019 | 5D (HD) | 108 | Neutral | Female gender OR 0.56 (0.15–2.06), p = 0.38 | Severe AAC measured by abdomen lateral plain radiograph | (152) |
| Wang *et al.* | China | 2014 | 5D (HD) | 77 | Male at risk | female gender OR = 0.20 (0.07–0.55) | CACS using 256-detector-row Brilliance iCT scanner of the of the left main, left anterior descending, left  circumflex, and right coronary arteries | (153) |
| Yamada *et al.* | Japan | 2008 | 5D (HD) | 49 | Male at risk | Female β = -0.178, p = 0.0345 | Vascular  calcification of the hand arteries distal to the wrist joints | (154) |
| Zhang et al. | China | 2019 | 5D (HD) | 105 | Male gender (male = 1, female = 2) | Correlation coefficient = -0.211, p = 0.03 | Interventricular septal thickness (IVST) | (155) |
| Zhang et al. |  |  |  |  |  | Lower A-Klotho -> higher IVST; Female thinner IVST |  |  |
| Zou *et al.* | China | 2020 | 5D | 165 | Male at risk (subgroup) | Among PD patients, male β = 0.259 (0.052–0.416), p = 0.012 | Serum sclerostin | (156) |
| Zou *et al.* | China | 2016 | 1-5 (pre-dialysis) | 296 | Male at risk | β = 9.21, SE = 3.61, p = 0.01 | LVMI (g/m2) | (157) |
| Zou *et al.* |  |  | Supplemental table看不到 |  |  |  |  |  |

Table 3. Modifiers of vascular calcification

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Author | Country | Time | CKD stages | sample | Findings | Data | Potential modifiers | Ref |
| Aoun *et al.* | Lebanon | 2017 | 5D (HD) | 50 | Male at risk | dp-ucMGP < vs. > 5000, female 68.3% vs. 22.2%, p = 0.02 | Dp-ucMGP | (158) |
| Axelsson *et al.* | Sweden | 2008 | 5 | 198 | Male at risk | Male vs. female to total fat mass: β = –1.68, SE = 0.41, p < 0.001 | Total fat mass correlates to fetuin-A | (159) |
| Barreto *et al.* | France | 2009 | 2-5D | 140 | Neutral | Male in 25D ≤ 16.7 ng/ml vs. 25D ≥ 16.7 ng/ml: 59% vs. 62%, p = 0.702 | 25D | (160) |
| Block et al. | United States | 1998 | 5D (HD) | 6407 | Female at risk | Male OR 0.774, p = 0.0001 | Serum phosphorus > 6.5 mg/dL | (161) |
| Block et al. |  |  |  |  |  | Female -> higher serum phosphorus |  |  |
| Block *et al.* | United States | 2007 | 5D (HD) | 127 | Neutral | Male in patients using Sevelamer vs. Calcium salts: 58% vs. 64%, p > 0.05 | Calcium-containing phosphate binder | (162) |
| Buiten MS | Netherlands | 2014 | 5D | 127 | Female gender | <460 pg/mL vs. >460 pg/mL: 16% vs 31%, p < 0.05 | Klotho | (163) |
| Cai *et al.* | China | 2015 | 5D (HD) | 129 | Neutral | Quartile I vs. II vs. III vs. IV, male 59.4% vs. 54.5% vs. 56.3% vs. 53.1%, p > 0.05 | Soluble Klotho | (101) |
| Cavallari *et al.* | Italy | 2019 | 5D | 30 | Neutral | Female in patients undergoing mixed online hemodiafiltration vs. bicarbonate hemodialysis: 23% vs. 33%, p = 0.2 | mOL-HDF inhibits vascualr calcification in VSMC | (164) |
| Chae *et al.* | Korea | 2018 | 1-5 | 1832 | Neutral | Female in quartile 1 vs. 2 vs. 3 vs. 4 of serum OPG: 36.2 vs. 43.4 vs. 42.5 vs. 38.6, p for trend = 0.517 | Serum OPG | (102) |
| Chang et al. | Republic of Korea | 2012 | 5D (HD) | 289 | Female at risk | Female OR 3.892 (1.678–9.025) | Vitamin D (25D) deficiency | (12) |
| Chao *et al.* | Taiwan | 2019 | 5D | 223 | Neutral | Female in patients with high vs. low miRNA-125b: 63% vs. 51%, p = 0.14 | miRNA-125b | (165) |
| Chen *et al.* | Taiwan | 2013 | 5D (HD) | 238 | Undetermined? | Male HR 0.92 (0.8–0.98) | Fetuin-A | (166) |
| Chen *et al.* |  |  |  |  | Undetermined? | Female HR 0.87 (0.74–0.92) |  |  |
| Choi *et al.* | Korea | 2019 | 5D (HD) | 97 | Neutral | 2 vs. 1 vs. 0 malnutrition and inflammation markers, male 61.5% vs. 41.9% vs 34.1%, p = 0.216 | Malnutrition and inflammation markers | (19) |
| Chou *et al.* | Taiwan | 2018 | 5D | 49 | Neutral | Male in symptomatic secondary hyperparathyroidism compared with in control patients under hemodialysis:  34.7% vs. 38.5%, p = 1.0 | SSHT | (167) |
| Claes *et al.* | Belgium | 2013 | 1-5 | 154 | Male at risk | In multivariate regression analysis, older  age (P < .0001), male sex (P = .006), lower eGFR ( P =  .0008), the absence of calcification (P = .006), lower bsAP  levels (P = .03), and lower cholesterol levels (P = .03) were  identified as independent determinants of higher levels of  circulating sclerostin. | Circulating sclerostin | (168) |
| Evenpoel *et al.* | Belgium | 2015 | 5T | 268 | Male gender | P = 0.002 | Sclerostin | (104) |
| Evenpoel *et al.* |  |  |  |  |  | In multivariate regression analysis, higher age (P =.0001), **male gender (P =.002)**, lower eGFR (P =.002), lower PTH (P =.0001) and lower calcitriol levels (P =.05) were identified as independent determinants of higher levels of circulating **sclerostin**. |  |  |
| Flávia Letícia et al. | Brazil | 2014 | 5D (HD) | 91 | Neutral | Low vs High sclerostin, Male/Female 24/22 vs. 31/14, p = 0.103 | Sclerostin | (169) |
| Gupta V | Hungary | 2021 | 5D (HD) | 982 | Male gender | Low (<3.20) vs. Med (3.20–4.39) vs. High (>4.39): 63% vs. 57% vs. 52% | OPG tertiles (pmol/L) | (170) |
| Hermans *et al.* | Netherlands | 2007 | 5D | 987 | More male receiving PD | Male in patients undergoing HD vs. PD: 57% vs. 64%, p = 0.028 | Dialysis types | (171) |
| Holden *et al.* | Canada | 2014 | 3-5 | 167 | Neutral | Male in VKORC1 CC vs. CG/GG: 68% vs. 55%, p = 0.11 | VKORC1 (vitamin K epoxide reductase complex 1) | (172) |
| Holden *et al.* |  |  |  |  |  | mutation into CC/CG increases the risk of vascular calcification |  |  |
| Ikee *et al.* | Japan | 2016 | 5D (HD) | 86 | Neutral | Mg level in male vs. female: 2.51 ± 0.38 vs. 2.42 ± 0.33 | Mg (mg/dL) | (173) |
| Iseki *et al.* | Japan | 2003 | 5D (HD) | 1243 | Male longer HD vintage | Male in patients with duration of HD 1-12 vs. ≥121 months: 50.2% vs. 67.0%, p < 0.001 | HD vintage | (174) |
| Jean *et al.* | France | 2011 | 5D (HD) | 1138 | Neutral | Female in patients with serum PTH < 50 pg/mL vs. ≥ 50 pg/mL: 43% vs. 40%, p > 0.05 | Serum PTH (pg/mL) | (175) |
| Karsli Ceppioğlu *et al.* | Turkey | 2011 | 3-5 | 84 | Female at risk | The concentration of Cu was significantly increased in women subjects (p = 0.002) | Oxidative stress | (176) |
| Karsli Ceppioğlu *et al.* |  |  |  |  | Neutral | DNA damage not associated with gender | matrix Gla protein (MGP) gene |  |
| Kato *et al.* | Japan | 2009 | 5D (HD) | 68 | Neutral | Serum PBEF/visfatin was significantly and positively correlated with HD duration (r = 0.30, p = 0.01), but did not correlate with age, gender and diabetes. | Serum PBEF/visfatin | (177) |
| Kuo et al. | Taiwan | 2019 | 5D (PD) | 89 | Male gender | OR 2.882 (1.219–6.815) | above-median sclerostin levels | (178) |
| Liabeuf *et al.* | France | 2013 | 2-5, 5D | 139 | Neutral | Free p-cresylglucuronide ≤ vs. ≥ 0.041 mg/dL, male 63% vs. 57%, p = 0.5 | Free p-cresylglucuronide | (179) |
| Metry *et al.* | Sweden | 2008 | 5D (HD) | 222 | Neutral | Male in group 1 vs. 2 vs. 3 vs. 4: 60.9% vs. 52.5% vs. 44.4% vs. 58.8%, p > 0.05 | Fetuin-A; Group I included patients who had high fetuin-A and low CRP (reference group); Group II included patients who had high fetuin-A and high CRP; Group III included patients who had low fetuin-A and low CRP; Group IV included patients who had low fetuin-A and high CRP | (180) |
| Miyatake *et al.* | Japan | 2020 | 5T | 50 | Neutral (CTRP9) | LDL-C, male vs. female 113.0 (97.0–132.5) vs. 90.0 (76.5–98.3), p < 0.01  HDL-C, male vs. female 57.0 (51.0–67.0) vs. 78.0 (66.8–96.5), p < 0.01  HMW-ADPN, male vs. female 2.48 (1.62–3.33) vs. 4.52 (3.02–6.79), p < 0.01  LMW-ADPN, male vs. female 1.67 (1.14–1.89) vs. 2.26 (1.85–2.83), p < 0.01  CTRP9, male vs. female 2.08 (2.01–2.13) vs. 2.03 (2.00–2.07), p > 0.05 | Circulating CTRP9 | (62) |
| Miyatake *et al.* |  |  |  |  | Neutral (CTRP9) | Female β = -0.089, p = 0.590 |  |  |
| Nakashima *et al.* | Japan | 2010 | 5D (HD) | 151 | Neutral | Parameter estimate = 0.531, SE = 0.814, p = 0.51 | Osteoprotegerin (pmol/L) | (181) |
| Nemeth ZK | Hungary | 2015 | 5T | 993 | Male gender (%) | 1st (<3.20) vs. 2nd (3.20–4.39) vs. 3rd (>4.39): 63% vs. 58% vs. 52%, p = 0.02 | Serum OPG tertiles (pmol/L) | (132) |
| Nithiya *et al.* | India | 2020 | 5D | 113 | Neutral | Male in patients with vs. without pulmonary hypertension: 47.2% vs. 52.8%, p = 0.683 | PHTN | (182) |
| Okamoto *et al.* | Japan | 2018 | 5D (HD) | 230 | Neutral | Low vs. non-low fetuin-A, male 61% vs. 68%, p = 0.400 | Fetuin-A | (183) |
| Park *et al.* | Korean | 2018 | 1-5 | 1741 | Female more severe | ECF quartile 1 vs. 2 vs. 3 vs. 4, male 80.6% vs. 59.0% vs. 39.7% vs. 39.6, p < 0.001  Male β = 0.509 (0.660–0.359), p < 0.001 (Univariate)  Male β = 0.095 (0.421–0.231), p = 0.566 (Multivariate) | ECF excess | (184) |
| Peyro-Shabani A | Iran | 2018 | 5D (HD) | 84 | Female gender | ACI score 0-40 vs. 41-80 vs. 81-120: 3.48±1.18 vs. 4.54±0.93 vs. 3.80±1.04, p = 0.01 | P (mg/dL)(mean ± SD) | (185) |
| Peyro-Shabani A |  |  |  |  | Male gender | ACI score 0-40 vs. 41-80 vs. 81-120: 298 (68-2630) vs. 287 (166-892) vs. 540 (391-698), p = 0.02 | Alkaline phosphate (U/L)(median (min-max)) |  |
| Riphagen *et al.* | Netherlands | 2017 | Not CKD | 4275 | Male gender | <275 vs. 275–479 vs. ≥480: 40.0% vs. 46.9% vs. 51.0% | dp-ucMGP (/pmol/L) | (186) |
| Riphagen *et al.* |  |  |  |  |  | Not CKD |  |  |
| Schlieper *et al.* | Serbia | 2011 | 5 | 188 | Neutral | dp-cMGP > vs. < 6139 pmol/L, male OR 0.62 (0.35–1.11), p = 0.11 | Dp-cMGP | (187) |
| Shiga et al. | Japan | 2011 | Not all CKD | 289 | Male has higher PEDF | PEDF in Male vs. female: 19.8 ± 6.0 vs. 17.4 ± 5.8, p = 0.001 | PEDF, µg/ml | (188) |
| Shimoyama *et al.* | Japan | 2012 | 5D (HD) | 219 | Male at risk | CACS was significantly high in C allele carriers of  rs2273773 in all and male HD patients. | C carrier of SIRT1 mutation | (189) |
| Shimoyama *et al.* |  |  |  |  |  | C:\Users\patricia\AppData\Local\Temp\vmware-patricia\VMwareDnD\56aaf0d5\2021-04-29 17-32-01 的螢幕擷圖.png |  |  |
| Sigrist *et al.* | United Kindom | 2009 | 3-4 | 134 | Neutral | Male in patients with OPG ≤25 pmol/L vs. >25 pmol/L: 63% vs. 70%, p = 0.47 | Serum OPG | (190) |
| Stenvinkel *et al.* | Sweden | 2005 | 5 | 258 | Neutral | No differences in the median fetuin-A level were noted between nonsmokers and former/current smokers (0.247 vs. 0.217 g/L), or between males and females (0.225 vs. 0.223 g/L). | Fetuin-A | (191) |
| Stolic *et al.* | Serbia | 2016 | 5D (HD) | 88 | Neutral | Male vs. Female (mean [range]): 1.2 (0.7–1.6) vs. 1.2 (0.8–1.5), p = 0.896 | Magnesium (mmol/L), whose insufficiency predicts vascular calcification | (192) |
| Thambiah *et al.* | United Kindom | 2012 | 3B-4 | 77 | Male at risk | β = 0.23, p = 0.024 | Serum sclerostin predicts vascular calcification | (193) |
| Ulusoy *et al.* | Turkey | 2012 | 5D (HD) | 103 | Male at risk | In pre-hemodialysis, male patients' SCUBE1 level was significantly higher than that of females (p=0.000). | SCUBE1 | (194) |
| Viaene *et al.* | Belgium | 2013 | 5D (HD) | 100 | Neutral | Female in patients with sclerostin < median vs. > median: 47% vs. 35%, p = 0.2 | Sclerostin level | (195) |
| Wang *et al.* | China (Hong Kong) | 2014 | 3-5 | 300 | Male gender negatively correlated | Partial correlation coefficient = -0.14, p = 0.02 | Tissue advanced glycation end products (reflected by skin autofluorescence) | (89) |
| Yoshikawa *et al.* | Japan | 2013 | 5D (HD) | 134 | Neutral | Male in patients with CC vs. CT vs. TT genotype of T-138C: 14% vs. 48% vs. 33%, p = 0.53 | Genotype of T-138C, CT/TT genotype predicts AACVS | (92) |
| Zhang *et al* | China | 2019 | 5D (HD) | 105 | Neutral | Male in ≤25th vs. 25-50th vs. 50-75th vs. ≥75th percentile: 57.7% vs.48.1% vs. 46.2% vs. 65.4%, p = 0.473 | Serum s-Klotho level | (155) |
| Zhang *et al.* | China | 2015 | 5D (HD) | 90 | Male at risk | Male to serum ACE2: Correlation coefficient = 0.362, p < 0.001 | Serum ACE2 levels predicts coronary artery calcium assessed with multi-slice CT (Agatston score) | (196) |
| Zhang *et al.* | China | 2013 | 5D (HD) | Cohort 1: 72  Cohort 2: 139  Cohort 3: 508 | Neutral | Female in patients receiving 1.75 mmol/L vs. 1.5 mmol/L dialysate calcium concentration: 53.3% vs. 44.8 %, p = 0.070 | DCa | (197) |
| Zou *et al.* | China | 2016 | 1-5 (pre-dialysis) | 296 | Neutral | Serum phosphorus tertile 1 vs. 2 vs. 3: 60.2% vs. 50.0% vs. 61.2%, p = 0.21 | Serum phosphorus | (157) |

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