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Review article

The 100 most-cited original articles in cardiac computed tomography: A bibliometric analysis

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ABSTRACT

Bibliometric analysis is the application of statistical methods to analyze quantitative data about scientific publications. It can evaluate research performance, author productivity, and manuscript impact. To the best of our knowledge, no bibliometric analysis has focused on cardiac computed tomography (CT). The purpose of this paper was to compile a list of the 100 most-cited articles related to cardiac CT literature using Scopus and Web of Science (WOS).

A list of the 100 most-cited articles was compiled by order of citation frequency, as well a list of the top 10 most-cited guideline and review articles and the 20 most-cited articles of the years 2014–2015. The database of 100 most-cited articles was analyzed to identify characteristics of highly cited publications. For each manuscript, the number of authors, study design, size of patient cohort and departmental affiliations were cataloged.

The 100 most-cited articles were published from 1990 to 2012, with the majority (53) published between 2005 and 2009. The total number of citations varied from 3354 to 196, and the number of citations per year varied from 9.5 to 129.0 with a median and mean of 30.9 and 38.7, respectively. The majority of publications had a study patients sample size of 200 patients or less. The USA and Germany were the nations with the highest number of frequently cited publications.

This bibliometric analysis provides insights on the most-cited articles published on the subject of cardiac CT and calcium volume, thus helping to characterize the field and guide future research.

1. Introduction

Bibliometric analysis is the application of statistical methods to analyze and report quantitative data about scientific publications. It can be used to evaluate research performance, author productivity, and manuscript impact. Citation analysis, a component of bibliometric analyses, is a useful way to assess the impact or influence an article has on its field and to characterize the field itself.[1–4]

Several specialties and journals have previously published lists of the most-cited articles in their field.[5–15] In diagnostic radiology, four bibliometric analyses of the 100 most-cited articles have recently been published.[5,11,14,15] To the best of our knowledge, no current bibliometric analysis has focused on cardiac computed tomography (cardiac CT).

The purpose of this bibliometric analysis was to compile and examine the 100 most-cited articles relating to cardiac CT across all peer-reviewed scientific journals. The analysis was not limited to radiology journals as to provide a list of the most influential articles across all domains of medicine. This bibliometric citation analysis reflects the most influential articles to date related to cardiac CT, and may facilitate the identification of current trends in cardiac CT research.

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2. Materials and methods

A bibliometric analysis of the most-cited articles in cardiac CT was conducted in April 2016. All journals from Elsevier's Scopus and Thomson Reuters' Web of Science (WOS) were eligible for inclusion, comprising over 22,000 and 12,000 of the most-cited journals in the world, respectively. All journals were selected for inclusion regardless of country of origin, language, medical specialty, or electronic availability of articles or abstracts.

The key-word based database search was formulated in consultation with a medical information specialist and consisted of a series of cardiac search terms combined with a series of radiology search terms. Cardiac search terms were: coronary, calcium, coronary angiography, cardiac, fractional flow reserve (FFR), transcatheter aortic valve replacement (TAVR), coronary CTA, stenosis, plaque, CONFIRM (COronary CT Angiography EvaluatioN For Clinical Outocmes: An InteRnational Multicenter) registry, and atherosclerosis. Radiology search terms were: computed tomography, CT, MDCT, EBCT, and emergency room use of CTA. The terms were combined as follows:

(Coronary OR "Cardiac" OR "Calcium" OR "Coronary Angiography" OR
("FFR" OR "Fractional Flow Reserve") OR
("TAVR" OR "Transcatheter Aortic Valve Replacement") OR
("COronary CT Angiography EvaluatioN For Clinical Outocmes" OR
("CONFIRM" AND "CCTA")) OR
(("Stenosis" OR "Plaque" OR "Atherosclerosis" OR
("Emergency" AND "CTA" OR "Computed Tomography Angiography")) AND
("Cardiac" OR "Coronary"))) AND
("Computed Tomography" OR "CT" OR "MDCT" OR "EBCT")

Each article was reviewed for its appropriateness for inclusion. The articles were independently reviewed by two board-certified and fellowship trained staff radiologists with over 20 years combined experience in reading cardiac CT. A third staff radiologist resolved differences in opinion with regards to article inclusion.

The inclusion criteria specified articles that focused on cardiac CT and coronary calcium. Articles were excluded if they did not relate to cardiac radiology, explored basic science research, or did not include human subjects (e.g. research with phantoms). Review articles, guidelines, and meta-analyses were also excluded from the 100 most cited article list.

The 100 most-cited articles were compiled in a single database. The abstracts and articles included in the list of the top 100 most-cited articles were compiled and analyzed using the methods of Lim et al.[10] The database included: Article Title, WOS all database citations, WOS Core Collection citations, Scopus citations, Year, Journal, Authors, Number of Authors, Department Affiliation, Number of Institutions, Country of Primary Institution, Study Type, Study Design, and Sample Size. The Scopus citation count is reported in the results.

An important limitation of this study was the potential for excluding relatively recent papers from the list of top 100 most-cited articles. Due to their recent publication, these papers would inherently have lower citation counts than their older counterparts. A second more focused search was performed in an attempt to address this. This was done by performing the same search with the same terms within a narrower time range (2014–2015) and selecting the top 20 most-cited articles.

As per design of this study, non-original articles, namely review articles and guidelines were excluded. In order to capture the most-cited non-original articles, a separate search was conducted to identify the top 10 most-cited review articles and guidelines.

3. Results

Table 1 shows the total number of citations and the average citations per year for the top 100 most-cited articles. The 3 most-cited articles were “Quantification of Coronary Artery Calcium Using Ultrafast Computed Tomography” with a total of 3354 citations,“Diagnostic Accuracy of Noninvasuve Coronary Angiography using 64-lsice Spiral Computed Tomography” with a total of 1196 citations, and “Cornary Artery Calcium Score Combined with Framingham Score for Risk Prediction in Asymptomatic Individuals” with a total of 1065 citations.

Table 1
The 100 most-cited articles in cardiac CT literature (Scopus and Web of Science).

Rank	Article	Total citations	Average citations per year
1	Agatston AS, Janowitz WR, Hildner FJ, Zusmer NR, Viamonte Jr. M, Detrano R. **Quantification of coronary artery calcium using ultrafast computed tomography**. J Am Coll Cardiol, 1990:827–32.	3354	129.0
2	Raff GL, Gallagher MJ, O'Neill WW, Goldstein JA. **Diagnostic accuracy of noninvasive coronary angiography using 64-slice spiral computed tomography**. J Am Coll Cardiol, 2005:552–7.	1196	108.7
3	Greenland P, LaBree L, Azen SP, Doherty TM, Detrano RC. **Coronary Artery Calcium Score Combined with Framingham Score for Risk Prediction in Asymptomatic Individuals**. Journal of the American Medical Association, 2004:210–5.	1065	88.8
4	Leber AW, Knez A, Von Ziegler F, Becker A, Nikolaou K, Paul S, Wintersperger B, Reiser M, Becker CR, Steinbeck G, Boekstegers P. **Quantification of obstructive and nonobstructive coronary lesions by 64-slice computed tomography: A comparative study with quantitative coronary angiography and intravascular ultrasound**. J Am Coll Cardiol, 2005:147–54.	1006	91.5
5	Budoff MJ, Dowe D, Jollis JG, Gitter M, Sutherland J, Halamert E, Scherer M, Bellinger R, Martin A, Benton R, Delago A, Min JK. **Diagnostic Performance of 64-Multidetector Row Coronary Computed Tomographic Angiography for Evaluation of Coronary Artery Stenosis in Individuals Without Known Coronary Artery Disease. Results From the Prospective Multicenter ACCURACY (Assessment by Coronary Computed Tomographic Angiography of Individuals Undergoing Invasive Coronary Angiography) Trial**. J Am Coll Cardiol, 2008:1724–32.	990	123.8
6	Rumberger JA, Simons DB, Fitzpatrick LA, Sheedy PF, Schwartz RS. **Coronary artery calcium area by electron-beam computed tomography and coronary atherosclerotic plaque area: A histopathologic correlative study**. Circulation, 1995:2157–62.	990	47.1
7	Miller JM, Rochitte CE, Dewey M, Arbab-Zadeh A, Niinuma H, Gottlieb I, Paul N, Clouse ME, Shapiro EP, Hoe J, Lardo AC, Bush DE, De Roos A, Cox C, Brinker J, Lima JAC. **Diagnostic performance of coronary angiography by 64-row CT**. N Engl J Med, 2008:2324–36.	946	118.3
8	Nieman K, Cademartiri F, Lemos PA, Raaijmakers R, Pattynama PMT, De Feyter PJ. **Reliable noninvasive coronary angiography with fast submillimeter multislice spiral computed tomography**. Circulation, 2002:2051–4.	882	63.0
9	Mollet NR, Cademartiri F, Van Mieghem CAG, Runza G, McFadden EP, Baks T, Serruys PW, Krestin GP, De Feyter PJ. **High-resolution spiral computed tomography coronary angiography in patients referred for diagnostic conventional coronary angiography**. Circulation, 2005:2318–23.	864	78.5

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Table 1 (*continued*)

Rank	Article	Total citations	Average citations per year
10	Ropers D, Baum U, Pohle K, Anders K, Ulzheimer S, Ohnesorge B, Schlundt C, Bautz W, Daniel WG, Achenbach S. **Detection of coronary artery stenoses with thin-slice multi-detector row spiral computed tomography and multiplanar reconstruction**. Circulation, 2003:664–6.	853	65.6
11	Leschka S, Alkadhi H, Plass A, Desbiolles L, Grünenfelder J, Marincek B, Wildermuth S. **Accuracy of MSCT coronary angiography with 64-slice technology: First experience**. Eur Heart J, 2005:1482–7.	848	77.1
12	Raggi P, Boulay A, Chasan-Taber S, Amin N, Dillon M, Burke SK, Chertow GM. **Cardiac calcification in adult hemodialysis patients: A link between end-stage renal disease and cardiovascular disease?** J Am Coll Cardiol, 2002:695–701.	760	54.3
13	Meijboom WB, Meijs MFL, Schuijf JD, Cramer MJ, Mollet NR, van Mieghem CAG, Nieman K, van Werkhoven JM, Pundziute G, Weustink AC, de Vos AM, Pugliese F, Rensing B, Jukema JW, Bax JJ, Prokop M, Doevendans PA, Hunink MGM, Krestin GP, de Feyter PJ. **Diagnostic Accuracy of 64-Slice Computed Tomography Coronary Angiography. A Prospective, Multicenter, Multivendor Study**. J Am Coll Cardiol, 2008:2135–44.	636	79.5
14	Nieman K, Oudkerk M, Rensing BJ, Van Ooijen P, Munne A, Van Geuns RJ, De Feyter PJ. **Coronary angiography with multi-slice computed tomography**. Lancet, 2001:599–603.	631	42.1
15	Braun J, Oldendorf M, Moshage W, Heidler R, Zeitler E, Luft FC. **Electron beam computed tomography in the evaluation of cardiac calcifications in chronic dialysis patients**. American Journal of Kidney Diseases, 1996:394–401.	630	31.5
16	Achenbach S, Giesler T, Ropers D, Ulzheimer S, Derlien H, Schulte C, Wenkel E, Moshage W, Bautz W, Daniel WG, Kalender WA, Baum U. **Detection of coronary artery stenoses by contrast-enhanced, retrospectively electrocardiographically-gated, multislice spiral computed tomography**. Circulation, 2001:2535–8.	620	41.3
17	Hausleiter J, Meyer T, Hermann F, Hadamitzky M, Krebs M, Gerber TC, McCollough C, Martinoff S, Kastrati A, Schömig A, Achenbach S. **Estimated radiation dose associated with cardiac CT angiography**. JAMA, 2009:500–7.	617	88.1
18	Achenbach S, Moselewski F, Ropers D, Ferencik M, Hoffmann U, MacNeill B, Pohle K, Baum U, Anders K, Jang IK, Daniel WG, Brady TJ. **Detection of Calcified and Noncalcified Coronary Atherosclerotic Plaque by Contrast-Enhanced, Submillimeter Multidetector Spiral Computed Tomography: A Segment-Based Comparison with Intravascular Ultrasound**. Circulation, 2004:14–7.	595	49.6
19	Arad Y, Spadaro LA, Goodman K, Newstein D, Guerci AD. **Prediction of coronary events with electron beam computed tomography**. J Am Coll Cardiol, 2000:1253–60.	573	35.8
20	Kondos GT, Hoff JA, Sevrukov A, Daviglus ML, Garside DB, Devries SS, Chomka EV, Liu K. **Electron-beam tomography coronary artery calcium and cardiac events: A 37-month follow-up of 5635 initially asymptomatic low- to intermediate-risk adults**. Circulation, 2003:2571–6.	563	43.3
21	Hausleiter J, Meyer T, Hadamitzky M, Huber E, Zankl M, Martinoff S, Kastrati A, Schömig A. **Radiation dose estimates from cardiac multislice computed tomography in daily practice: Impact of different scanning protocols on effective dose estimates**. Circulation, 2006:1305–10.	560	56.0
22	Motoyama S, Sarai M, Harigaya H, Anno H, Inoue K, Hara T, Naruse H, Ishii J, Hishida H, Wong ND, Virmani R, Kondo T, Ozaki Y, Narula J. **Computed Tomographic Angiography Characteristics of Atherosclerotic Plaques Subsequently Resulting in Acute Coronary Syndrome.** J Am Coll Cardiol, 2009:49–57.	550	78.6
23	Leber AW, Becker A, Knez A, Von Ziegler F, Sirol M, Nikolaou K, Ohnesorge B, Fayad ZA, Becker CR, Reiser M, Steinbeck G, Boekstegers P. **Accuracy of 64-slice computed tomography to classify and quantify plaque volumes in the proximal coronary system: A comparative study using intravascular ultrasound**. J Am Coll Cardiol, 2006:672–7.	543	54.3
24	Leber AW, Knez A, Becker A, Becker C, Von Ziegler F, Nikolaou K, Rist C, Reiser M, White C, Steinbeck G, Boekstegers P. **Accuracy of multidetector spiral computed tomography in identifying and differentiating the composition of coronary atherosclerotic plaques: A comparative study with intracoronary ultrasound**. J Am Coll Cardiol, 2004:1241–7.	521	43.4
25	Callister TQ, Cooil B, Raya SP, Lippolis NJ, Russo DJ, Raggi P. **Coronary artery disease: Improved reproducibility of calcium scoring with an electron-beam CT volumetric method**. Radiology, 1998:807–14.	513	28.5
26	Jakobs TF, Becker CR, Ohnesorge B, Flohr T, Suess C, Schoepf UJ, Reiser MF. **Multislice helical CT of the heart with retrospective ECG gating: reduction of radiation exposure by ECG-controlled tube current modulation**. Eur Radiol, 2002:1081–6.	507	36.2
27	Min JK, Shaw LJ, Devereux RB, Okin PM, Weinsaft JW, Russo DJ, Lippolis NJ, Berman DS, Callister TQ. **Prognostic Value of Multidetector Coronary Computed Tomographic Angiography for Prediction of All-Cause Mortality**. J Am Coll Cardiol, 2007:1161–70.	502	55.8
28	Motoyama S, Kondo T, Sarai M, Sugiura A, Harigaya H, Sato T, Inoue K, Okumura M, Ishii J, Anno H, Virmani R, Ozaki Y, Hishida H, Narula J. **Multislice Computed Tomographic Characteristics of Coronary Lesions in Acute Coronary Syndromes**. J Am Coll Cardiol, 2007:319–26.	469	52.1
29	Arad Y, Spadaro LA, Goodman K, Lledo-Perez A, Sherman S, Lerner G, Guerci AD. **Predictive value of electron beam computed tomography of the coronary arteries: 19-Month follow-up of 1173 asymptomatic subjects**. Circulation, 1996:1951–3.	457	22.9
30	Hoffmann MHK, Shi H, Schmitz BL, Schmid FT, Lieberknecht M, Schulze R, Ludwig B, Kroschel U, Jahnke N, Haerer W, Brambs HJ, Aschoff AJ. **Noninvasive coronary angiography with multislice computed tomography. Journal of the American Medical Association**, 2005:2471–8.	438	39.8
31	Goldstein JA, Gallagher MJ, O'Neill WW, Ross MA, O'Neil BJ, Raff GL. **A Randomized Controlled Trial of Multi-Slice Coronary Computed Tomography for Evaluation of Acute Chest Pain**. J Am Coll Cardiol, 2007:863–71.	426	47.3
32	Rybicki FJ, Otero HJ, Steigner ML, Vorobiof G, Nallamshetty L, Mitsouras D, Ersoy H, Mather RT, Judy PF, Cai T, Coyner K, Schultz K, Whitmore AG, Di Carli MF. **Initial evaluation of coronary images from 320-detector row computed tomography**. Int J Card Imaging, 2008:535–46.	412	51.5
33	Earls JP, Berman EL, Urban BA, Curry CA, Lane JL, Jennings RS, McCulloch CC, Hsieh J, Londt JH. **Prospectively gated transverse coronary CT angiography versus retrospectively gated helical technique: Improved image quality and reduced radiation dose**. Radiology, 2008:742–53.	409	51.1
34	Achenbach S, Ulzheimer S, Baum U, Kachelriess M, Ropers D, Giesler T, Bautz W, Daniel WG, Kalender WA, Moshage W. **Noninvasive coronary angiography by retrospectively ECG-gated multislice spiral CT**. Circulation, 2000:2823–8.	400	25.0
35	Husmann L, Valenta I, Gaemperli O, Adda O, Treyer V, Wyss CA, Veit-Haibach P, Tatsugami F, Von Schulthess GK, Kaufmann PA. **FASTTRACK - Feasibility of low-dose coronary CT angiography: First experience with prospective ECG-gating**. Eur Heart J, 2008:191–7.	389	48.6
36	Budoff MJ, Georgiou D, Brody A, Agatston AS, Kennedy J, Wolfkiel C, Stanford W, Shields P, Lewis RJ, Janowitz WR, Rich S, Brundage BH. **Ultrafast computed tomography as a diagnostic modality in the detection of coronary artery disease: A multicenter study**. Circulation, 1996:898–904.	388	19.4

Table 1 (*continued*)

Rank	Article	Total citations	Average citations per year
37	Pundziute G, Schuijf JD, Jukema JW, Boersma E, de Roos A, van der Wall EE, Bax JJ. **Prognostic Value of Multislice Computed Tomography Coronary Angiography in Patients With Known or Suspected Coronary Artery Disease**. J Am Coll Cardiol, 2007:62–70.	384	42.7
38	Mollet NR, Cademartiri F, Nieman K, Saia F, Lemos PA, McFadden EP, Pattynama PMT, Serruys PW, Krestin GP, De Feyter PJ. **Multislice spiral computed tomography coronary angiography in patients with stable angina pectoris**. J Am Coll Cardiol, 2004:2265–70.	378	31.5
39	Ropers D, Rixe J, Anders K, Küttner A, Baum U, Bautz W, Daniel WG, Achenbach S. Usefulness **of multidetector row spiral computed tomography with 64- x 0.6-mm collimation and 330-ms rotation for the noninvasive detection of significant coronary artery stenoses**. Am J Cardiol, 2006:343–8.	372	37.2
40	Scheffel H, Alkadhi H, Plass A, Vachenauer R, Desbiolles L, Gaemperli O, Schepis T, Frauenfelder T, Schertler T, Husmann L, Grunenfelder J, Genoni M, Kaufmann PA, Marincek B, Leschka S. **Accuracy of dual-source CT coronary angiography: First experience in a high pre-test probability population without heart rate control**. Eur Radiol, 2006:2739–47.	362	36.2
41	Hoffmann U, Moselewski F, Cury RC, Ferencik M, Jang IK, Diaz LJ, Abbara S, Brady TJ, Achenbach S. **Predictive value of 16-slice multidetector spiral computed tomography to detect significant obstructive coronary artery disease in patients at high risk for coronary artery disease: Patient- versus segment-based analysis**. Circulation, 2004:2638–43.	360	30.0
42	Achenbach S, Marwan M, Ropers D, Schepis T, Pflederer T, Anders K, Kuettner A, Daniel WG, Uder M, Lell MM. **Coronary computed tomography angiography with a consistent dose below 1 mSv using prospectively electrocardiogram-triggered high-pitch spiral acquisition**. Eur Heart J, 2010:340–6.	358	59.7
43	Achenbach S, Ropers D, Kuettner A, Flohr T, Ohnesorge B, Bruder H, Theessen H, Karakaya M, Daniel WG, Bautz W, Kalender WA, Anders K. **Contrast-enhanced coronary artery visualization by dual-source computed tomography - Initial experience**. Eur J Radiol, 2006:331–5.	354	35.4
44	Hoffmann U, Bamberg F, Chae CU, Nichols JH, Rogers IS, Seneviratne SK, Truong QA, Cury RC, Abbara S, Shapiro MD, Moloo J, Butler J, Ferencik M, Lee H, Jang IK, Parry BA, Brown DF, Udelson JE, Achenbach S, Brady TJ, Nagurney JT. **Coronary Computed Tomography Angiography for Early Triage of Patients With Acute Chest Pain. The ROMICAT (Rule Out Myocardial Infarction using Computer Assisted Tomography) Trial**. J Am Coll Cardiol, 2009:1642–50.	334	47.7
45	Wong ND, Hsu JC, Detrano RC, Diamond G, Eisenberg H, Gardin JM. **Coronary artery calcium evaluation by electron beam computed tomography and its relation to new cardiovascular events**. Am J Cardiol, 2000:495–8.	327	20.4
46	Hoffmann U, Moselewski F, Nieman K, Jang IK, Ferencik M, Rahman AM, Cury RC, Abbara S, Joneidi-Jafari H, Achenbach S, Brady TJ. **Noninvasive Assessment of Plaque Morphology and Composition in Culprit and Stable Lesions in Acute Coronary Syndrome and Stable Lesions in Stable Angina by Multidetector Computed Tomography**. J Am Coll Cardiol, 2006:1655–62.	320	32.0
47	Pugliese F, Mollet NRA, Runza G, van Mieghem C, Meijboom WB, Malagutti P, Baks T, Krestin GP, deFeyter PJ, Cademartiri F. **Diagnostic accuracy of non-invasive 64-slice CT coronary angiography in patients with stable angina pectoris**. Eur Radiol, 2006:575–82.	317	31.7
48	Schuijf JD, Wijns W, Jukema JW, Atsma DE, de Roos A, Lamb HJ, Stokkel MPM, Dibbets-Schneider P, Decramer I, De Bondt P, van der Wall EE, Vanhoenacker PK, Bax JJ. **Relationship Between Noninvasive Coronary Angiography With Multi-Slice Computed Tomography and Myocardial Perfusion Imaging**. J Am Coll Cardiol, 2006:2508–14.	316	31.6
49	Koo BK, Erglis A, Doh JH, Daniels DV, Jegere S, Kim HS, Dunning A, Defrance T, Lansky A, Leipsic J, Min JK. **Diagnosis of ischemia-causing coronary stenoses by noninvasive fractional flow reserve computed from coronary computed tomographic angiograms: Results from the prospective multicenter DISCOVER-FLOW (Diagnosis of Ischemia-Causing Stenoses Obtained Via Noninvasive Fractional Flow Reserve) study**. J Am Coll Cardiol, 2011:1989–97.	312	62.4
50	Achenbach S, Moshage W, Ropers D, Nossen J, Daniel WG. **Value of electron-beam computed tomography for the noninvasive detection of high-grade coronary-artery stenoses and occlusions**. N Engl J Med, 1998:1964–71.	310	17.2
51	Tops LF, Wood DA, Delgado V, Schuijf JD, Mayo JR, Pasupati S, Lamers FPL, van der Wall EE, Schalij MJ, Webb JG, Bax JJ. **Noninvasive Evaluation of the Aortic Root With Multislice Computed Tomography. Implications for Transcatheter Aortic Valve Replacement**. JACC Cardiovasc Imaging, 2008:321–30.	306	38.3
52	Sugeng L, Mor-Avi V, Weinert L, Niel J, Ebner C, Steringer-Mascherbauer R, Schmidt F, Galuschky C, Schummers G, Lang RM, Nesser HJ. **Quantitative assessment of left ventricular size and function: Side-by-side comparison of real-time three-dimensional echocardiography and computed tomography with magnetic resonance reference**. Circulation, 2006:654–61.	303	30.3
53	Johnson TRC, Nikolaou K, Wintersperger BJ, Leber AW, von Ziegler F, Rist C, Buhmann S, Knez A, Reiser MF, Becker CR. **Dual-source CT cardiac imaging: Initial experience**. Eur Radiol, 2006:1409–15.	300	30.0
54	Shuman WP, Branch KR, May JM, Mitsumori LM, Lockhart DW, Dubinsky TJ, Warren BH, Caldwell JH. **Prospective versus retrospective ECG gating for 64-detector CT of the coronary arteries: Comparison of image quality and patient radiation dose**. Radiology, 2008:431–7.	296	37.0
55	Mollet NR, Cademartiri F, Krestin GP, McFadden EP, Arampatzis CA, Serruys PW, De Feyter PJ. **Improved diagnostic accuracy with 16-row multi-slice computed tomography coronary angiography**. J Am Coll Cardiol, 2005:128–32.	282	25.6
56	Keelan PC, Bielak LF, Ashai K, Jamjoum LS, Denktas AE, Rumberger JA, Sheedy Ii PF, Peyser PA, Schwartz RS. **Long-term prognostic value of coronary calcification detected by electron-beam computed tomography in patients undergoing coronary angiography**. Circulation, 2001:412–7.	282	18.8
57	Min JK, Leipsic J, Pencina MJ, Berman DS, Koo BK, Van Mieghem C, Erglis A, Lin FY, Dunning AM, Apruzzese P, Budoff MJ, Cole JH, Jaffer FA, Leon MB, Malpeso J, Mancini GBJ, Park SJ, Schwartz RS, Shaw LJ, Mauri L. **Diagnostic accuracy of fractional flow reserve from anatomic CT angiography**. JAMA, 2012:1237–45.	280	70.0
58	Meijboom WB, Van Mieghem CAG, van Pelt N, Weustink A, Pugliese F, Mollet NR, Boersma E, Regar E, van Geuns RJ, de Jaegere PJ, Serruys PW, Krestin GP, de Feyter PJ. **Comprehensive Assessment of Coronary Artery Stenoses. Computed Tomography Coronary Angiography Versus Conventional Coronary Angiography and Correlation With Fractional Flow Reserve in Patients With Stable Angina**. J Am Coll Cardiol, 2008:636–43.	280	35.0
59	Hoffmann U, Nagurney JT, Moselewski F, Pena A, Ferencik M, Chae CU, Cury RC, Butler J, Abbara S, Brown DF, Manini A, Nichols JH, Achenbach S, Brady TJ. **Coronary multidetector computed tomography in the assessment of patients with acute chest pain**. Circulation, 2006:2251–60.	280	28.0
60	Giesler T, Baum U, Ropers D, Ulzheimer S, Wenkel E, Mennicke M, Bautz W, Kalender WA, Daniel WG, Achenbach S. **Noninvasive visualization of coronary arteries using contrast-enhanced multidetector CT: Influence of heart rate on image quality and stenosis detection**. Am J Roentgenol, 2002:911–6.	278	19.9
61	Kuettner A, Trabold T, Schroeder S, Feyer A, Beck T, Brueckner A, Heuschmid M, Burgstahler C, Kopp AF, Claussen CD. **Noninvasive detection of coronary lesions using 16-detector multislice spiral computed tomography technology: Initial clinical results**. J Am Coll Cardiol, 2004:1230–7.	275	22.9

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Table 1 (*continued*)

Rank	Article	Total citations	Average citations per year
62	Achenbach S, Ropers D, Hoffmann U, MacNeill B, Baum U, Pohle K, Brady TJ, Pomerantsev E, Ludwig J, Flachskampf FA, Wicky S, Jang IK, Daniel WG. **Assessment of coronary remodeling in stenotic and nonstenotic coronary atherosclerotic lesions by multidetector spiral computed tomography**. J Am Coll Cardiol, 2004:842–7.	272	22.7
63	Zheng Y, Barbu A, Georgescu B, Scheuering M, Comaniciu D. **Four-chamber heart modeling and automatic segmentation for 3-D cardiac CT volumes using marginal space learning and steerable features**. IEEE Trans Med Imaging, 2008:1668–81.	264	33.0
64	Mautner GC, Mautner SL, Froehlich J, Feuerstein IM, Proschan MA, Roberts WC, Doppman JL. **Coronary artery calcification: Assessment with electron beam CT and histomorphometric correlation**. Radiology, 1994:619–23.	262	11.9
65	Rubinshtein R, Halon DA, Gaspar T, Jaffe R, Karkabi B, Flugelman MY, Kogan A, Shapira R, Peled N, Lewis BS. **Usefulness of 64-slice cardiac computed tomographic angiography for diagnosing acute coronary syndromes and predicting clinical outcome in emergency department patients with chest pain of uncertain origin**. Circulation, 2007:1762–8.	259	28.8
66	Leschka S, Wildermuth S, Boehm T, Desbiolles L, Husmann L, Plass A, Koepfli P, Schepis T, Marincek B, Kaufmann PA, Alkadhi H. **Noninvasive coronary angiography with 64-Section CT: Effect of average heart rate and heart rate variability on image quality**. Radiology, 2006:378–85.	255	25.5
67	Kuettner A, Beck T, Drosch T, Kettering K, Heuschmid M, Burgstahler C, Claussen CD, Kopp AF, Schroeder S. **Diagnostic accuracy of noninvasive coronary imaging using 16-detector slice spiral computed tomography with 188 ms temporal resolution**. J Am Coll Cardiol, 2005:123–7.	254	23.1
68	He ZX, Hedrick TD, Pratt CM, Verani MS, Aquino V, Roberts R, Mahmarian JJ. **Severity of coronary artery calcification by electron beam computed tomography predicts silent myocardial ischemia**. Circulation, 2000:244–51.	251	15.7
69	Nikolaou K, Knez A, Rist C, Wintersperger BJ, Leber A, Johnson T, Reiser MF, Becker CR. **Accuracy of 64-MDCT in the diagnosis of ischemic heart disease.** Am J Roentgenol, 2006:111–7.	247	24.7
70	Hirai N, Horiguchi J, Fujioka C, Kiguchi M, Yamamoto H, Matsuura N, Kitagawa T, Teragawa H, Kohno N, Ito K. **Prospective versus retrospective ECG-gated 64-detector coronary CT angiography: Assessment of image quality, stenosis, and radiation dose**. Radiology, 2008:424–30.	242	30.3
71	Kopp AF, Schroeder S, Kuettner A, Baumbach A, Georg C, Kuzo R, Heuschmid M, Ohnesorge B, Karsch KR, Claussen CD. **Non-invasive coronary angiography with high resolution multidetector-row computed tomography: Results in 102 patients**. Eur Heart J, 2002:1714–25.	242	17.3
72	Becker CR, Kleffel T, Crispin A, Knez A, Young J, Schoepf UJ, Haberl R, Reiser MF. **Coronary artery calcium measurement: Agreement of multirow detector and electron beam CT**. Am J Roentgenol, 2001:1295–8.	242	16.1
73	Janowitz WR, Agatston AS, Kaplan G, Viamonte Jr. M. **Differences in prevalence and extent of coronary artery calcium detected by ultrafast computed tomography in asymptomatic men and women**. The American Journal of Cardiology, 1993:247–54.	242	10.5
74	Simons DB, Schwartz RS, Edwards WD, Sheedy PF, Breen JF, Rumberger JA. **Noninvasive definition of anatomic coronary artery disease by ultrafast computed tomographic scanning: A quantitative pathologic comparison study**. J Am Coll Cardiol, 1992:1118–26.	242	10.1
75	Martuscelli E, Romagnoli A, D'Eliseo A, Razzini C, Tomassini M, Sperandio M, Simonetti G, Romeo F. **Accuracy of thin-slice computed tomography in the detection of coronary stenoses**. Eur Heart J, 2004:1043–8.	241	20.1
76	Scheffel H, Alkadhi H, Leschka S, Plass A, Desbiolles L, Guber I, Krauss T, Gruenenfelder J, Genoni M, Luescher TF, Marincek B, Stolzmann P. **Low-dose CT coronary angiography in the step-and-shoot mode: Diagnostic performance**. Heart, 2008:1132–7.	240	30.0
77	Hoffmann MHK, Shi H, Manzke R, Schmid FT, De Vries L, Grass M, Brambs HJ, Aschoff AJ. **Noninvasive coronary angiography with 16-detector row CT: Effect of heart rate**. Radiology, 2005:86–97.	240	21.8
78	Garcia MJ, Lessick J, Hoffmann MHK. **Accuracy of 16-row multidetector computed tomography for the assessment of coronary artery stenosis**. Journal of the American Medical Association, 2006:403–11.	239	23.9
79	van Werkhoven JM, Schuijf JD, Gaemperli O, Jukema JW, Boersma E, Wijns W, Stolzmann P, Alkadhi H, Valenta I, Stokkel MPM, Kroft LJ, de Roos A, Pundziute G, Scholte A, van der Wall EE, Kaufmann PA, Bax JJ. **Prognostic Value of Multislice Computed Tomography and Gated Single-Photon Emission Computed Tomography in Patients With Suspected Coronary Artery Disease**. J Am Coll Cardiol, 2009:623–32.	237	33.9
80	Achenbach S, Ropers D, Holle J, Muschiol G, Daniel WC, Moshage W. **In-plane coronary arterial motion velocity: Measurement with electron- beam CT**. Radiology, 2000:457–63.	236	14.8
81	Leber AW, Johnson T, Becker A, Von Ziegler F, Tittus J, Nikolaou K, Reiser M, Steinbeck G, Becker CR, Knez A. **Diagnostic accuracy of dual-source multi-slice CT-coronary angiography in patients with an intermediate pretest likelihood for coronary artery disease**. Eur Heart J, 2007:2354–60.	235	26.1
82	Hong C, Becker CR, Huber A, Schoepf UJ, Ohnesorge B, Knez A, Brüning R, Reiser MF. **ECG-gated reconstructed multi-detector row CT coronary angiography: Effect of varying trigger delay on image quality**. Radiology, 2001:712–7.	235	15.7
83	Breen JF, Sheedy Ii PF, Schwartz RS, Stanson AW, Kaufmann RB, Moll PP, Rumberger JA. **Coronary artery calcification detected with ultrafast CT as an indication of coronary artery disease. Work in progress**. Radiology, 1992:435–9.	228	9.5
84	Ostrom MP, Gopal A, Ahmadi N, Nasir K, Yang E, Kakadiaris I, Flores F, Mao SS, Budoff MJ. **Mortality Incidence and the Severity of Coronary Atherosclerosis Assessed by Computed Tomography Angiography**. J Am Coll Cardiol, 2008:1335–43.	227	28.4
85	Baumgart D, Schmermund A, Goerge G, Haude M, Ge J, Adamzik M, Sehnert C, Altmaier K, Groenemeyer D, Seibel R, Erbel R. **Comparison of electron beam computed tomography with intracoronary ultrasound and coronary angiography for detection of coronary atherosclerosis**. J Am Coll Cardiol, 1997:57–64.	223	11.7
86	Meijboom WB, van Mieghem CAG, Mollet NR, Pugliese F, Weustink AC, van Pelt N, Cademartiri F, Nieman K, Boersma E, de Jaegere P, Krestin GP, de Feyter PJ. **64-Slice Computed Tomography Coronary Angiography in Patients With High, Intermediate, or Low Pretest Probability of Significant Coronary Artery Disease**. J Am Coll Cardiol, 2007:1469–75.	220	24.4
87	Juergens KU, Grude M, Maintz D, Fallenberg EM, Wichter T, Heindel W, Fischbach R. **Multi-Detector Row CT of Left Ventricular Function with Dedicated Analysis Software versus MR Imaging: Initial Experience**. Radiology, 2004:403–10.	216	18.0
88	Coles DR, Smail MA, Negus IS, Wilde P, Oberhoff M, Karsch KR, Baumbach A. **Comparison of Radiation Doses From Multislice Computed Tomography Coronary Angiography and Conventional Diagnostic Angiography**. J Am Coll Cardiol, 2006:1840–5.	214	21.4
89	Jilaihawi H, Kashif M, Fontana G, Furugen A, Shiota T, Friede G, Makhija R, Doctor N, Leon MB, Makkar RR. **Cross-sectional computed tomographic assessment improves accuracy of aortic annular sizing fortranscatheter aortic valve replacement and reduces the incidence of paravalvular aortic regurgitation**. J Am Coll Cardiol, 2012:1275–86.	209	52.3
90	Schlosser T, Konorza T, Hunold P, Kühl H, Schmermund A, Barkhausen J. **Noninvasive visualization of coronary artery bypass grafts using 16-detector row computed tomography**. J Am Coll Cardiol, 2004:1224–9.	209	17.4
91	Choi EK, Choi SI, Rivera JJ, Nasir K, Chang SA, Chun EJ, Kim HK, Choi DJ, Blumenthal RS, Chang HJ. **Coronary Computed Tomography Angiography as a Screening Tool for the Detection of Occult Coronary Artery Disease in Asymptomatic Individuals**. J Am Coll Cardiol, 2008:357–65.	207	25.9

Table 1 (*continued*)

Rank	Article	Total citations	Average citations per year
92	Schuijf JD, Pundziute G, Jukema JW, Lamb HJ, van der Hoeven BL, de Roos A, van der Wall EE, Bax JJ. **Diagnostic Accuracy of 64-Slice Multislice Computed Tomography in the Noninvasive Evaluation of Significant Coronary Artery Disease**. Am J Cardiol, 2006:145–8.	207	20.7
93	Stolzmann P, Leschka S, Scheffel H, Krauss T, Desbiolles L, Plass A, Genoni M, Flohr TG, Wildermuth S, Marincek B, Alkadhi H. **Dual-source CT in step-and-shoot mode: Noninvasive coronary angiography with low radiation dose**. Radiology, 2008:71–80.	203	25.4
94	Nieman K, Rensing BJ, Van Geuns RJM, Vos J, Pattynama PMT, Krestin GP, Serruys PW, De Feyter PJ. **Non-invasive coronary angiography with multislice spiral computed tomography: Impact of heart rate**. Heart, 2002:470–4.	203	14.5
95	Gallagher MJ, Ross MA, Raff GL, Goldstein JA, O'Neill WW, O'Neil B. **The Diagnostic Accuracy of 64-Slice Computed Tomography Coronary Angiography Compared With Stress Nuclear Imaging in Emergency Department Low-Risk Chest Pain Patients**. Annals of Emergency Medicine, 2007:125–36.	199	22.1
96	Carr JJ, Crouse Iii JR, Goff Jr. DC, D'Agostino Jr. RB, Peterson NP, Burke GL. **Evaluation of subsecond gated helical CT for quantification of coronary artery calcium and comparison with electron beam CT**. Am J Roentgenol, 2000:915–21.	199	12.4
97	Pohle K, Achenbach S, MacNeill B, Ropers D, Ferencik M, Moselewski F, Hoffmann U, Brady TJ, Jang Ik, Daniel WG. **Characterization of non-calcified coronary atherosclerotic plaque by multi-detector row CT: Comparison to IVUS**. Atherosclerosis, 2007:174–80.	198	22.0
98	Kuettner A, Kopp AF, Schroeder S, Rieger T, Brunn J, Meisner C, Heuschmid M, Trabold T, Burgstahler C, Martensen J, Schoebel W, Selbmann HK, Claussen CD. **Diagnostic accuracy of multidetector computed tomography coronary angiography in with angiographically proven coronary artery disease patients**. J Am Coll Cardiol, 2004:831–9.	198	16.5
99	Kopp AF, Schroeder S, Kuettner A, Heuschmid M, Georg C, Ohnesorge B, Kuzo R, Claussen CD. **Coronary arteries: Retrospectively ECG-gated multi-detector row CT angiography with selective optimization of the image reconstruction window**. Radiology, 2001:683–8.	196	13.1
100	Ehara M, Surmely JF, Kawai M, Katoh O, Matsubara T, Terashima M, Tsuchikane E, Kinoshita Y, Suzuki T, Ito T, Takeda Y, Nasu K, Tanaka N, Murata A, Suzuki Y, Sato K, Suzuki T. **Diagnostic accuracy of 64-slice computed tomography for detecting angiographically significant coronary artery stenosis in an unselected consecutive patient population - Comparison with conventional invasive angiography**. Circ J, 2006:564–71.	196	19.6

3.1. Citations per year

The average number of citations per year varied from 9.5 to 129.0 with a median and mean of 30.9 and 38.7, respectively.

The article with the highest number of citations "Quantification of Coronary Artery Calcium Using Ultrafast Computer Tomography" also had the highest number of average citations per year at 129.

3.2. Year of publication

The 100 most-cited articles were published within the period from 1990 to 2012, and within this group the mean number of years from an article's date of publication is 11.89 years. Fig. 1 presents the distribution of the 100 most highly-cited articles since 1990 with 2005–2009 as the time period that produced the greatest number of highly-cited articles (53 articles).

3.3. Number of authors

The total number of unique authors contributing to the 100 most-cited articles is 157, with the number of authors per paper ranging from 3 to 21. The 10 most frequently cited authors contributed 92 articles to the list and are identified in Table 2. The mean and median number of authors per article was 10.

3.4. Departmental affiliation

An analysis of the departmental affiliations of the 100 most-cited articles showed that cardiology (n = 54), radiology (n = 32) and dual-appointed cardiology and radiology (n = 9) were the most common department affiliations of first authors, which reflects the pattern seen of last authors. Other affiliations included nephrology, preventative health, preventative cardiology, and corporate.

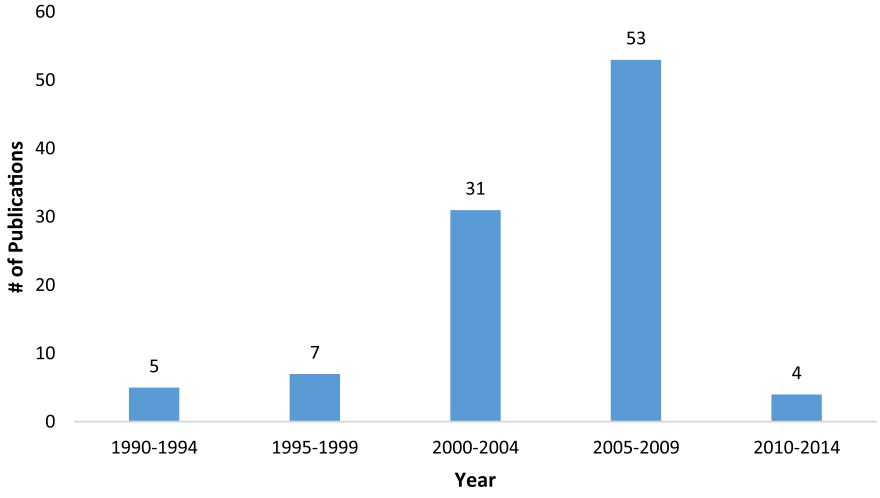

Fig. 1. Distribution of the 100 most highly-cited articles since 1990.

Table 2
Top 10 authors and the number of publications that they contributed to in the 100 most-cited list.

Rank	Authors	Publications (n)
1	Achenbach, S.	17
2	Ropers, D.	12
3	Daniel, W.G.	11
4	Becker, C.R.	8
5	Knez, A.	8
6	Krestin, G.P.	8
7	Kuettner, A.	7
8	Brady, T.J.	7
9	Nieman, K.	7
10	Baum, U.	7

Table 3
Distribution of articles for all journals publishing more than 1 article in the list.

Rank	Journal	Frequency (n)
1	Journal of the American College of Cardiology	34
2	Circulation	17
3	Radiology	13
4	European Heart Journal	6
5	Journal of the American Medical Association	5
6	American Journal of Cardiology	4
7	American Journal of Roentgenology	4
8	European Radiology	4
9	Heart	2
10	New England Journal of Medicine	2

3.5. Journals

The 100 most-cited articles were published among 17 different journals with the top 3 producing two thirds of the articles[1]: Journal of the American College of Cardiology,[2] Circulation, and[3] Radiology. Table 3 provides the distribution of articles for all journals publishing more than 1 article in the list.

3.6. Study designs

Study designs of the 100 most-cited articles were most often prospective (n = 86) with retrospective studies (n = 9) and time-independent studies (e.g. cross-sectional studies) making up a minority (n = 5). As displayed in Table 4, diagnostic accuracy studies (54%) comprised the largest component of the articles list, descriptive studies (23%) most often pertaining to dose and image quality optimization constituting the second most common design.

3.7. Additional descriptors

Other descriptors of the 100 most-cited articles used to categorize each article are summarized in Table 4 and include sample size, country of origin, primary topic/purpose, and affiliated departments/institutions.

3.8. Recent articles

An inherent limitation of the citation-based searching method is that recent important articles may not be captured because they have

Table 4
Analysis of articles from the 100 most cited list.

	Descriptors		Frequency (%)
Study design (n = 100)	Prospective diagnostic accuracy		52 (52%)
	Retrospective diagnostic accuracy		2 (2%)
	Prospective descriptive		18 (18%)
	Retrospective descriptive		5 (5%)
	Prospective cohort		15 (15%)
	Retrospective cohort		1 (1%)
	Randomized controlled trial		1 (1%)
	Cross-sectional		5 (5%)
	Case-control		1 (1%)
Sample size (n = 100, mean = 375, median = 87)	0–49		20
	50–99		33
	100–199		21
	200–299		8
	300–399		2
	400–499		0
	500–999		4
	1000–4999		11
	5000–9999		1
Country of origin (n = 100)	USA		36 (36%)
	Germany		33 (33%)
	Netherlands		15 (15%)
	Multi-national		2 (2%)
	Other		14 (14%)
Number of institutional affiliations (n = 100)	1		49 (49%)
	2		25 (25%)
	3		10 (10%)
	3–10		15 (15%)
	>10		1 (1%)
Topics (n = 100)	Contrast enhanced CT	Stenosis diagnostic accuracy	35 (35%)
		Outcome correlation	9 (9%)
		Plaque characteristics	10 (10%)
		Image quality and/or dose optimization	20 (20%)
		Ejection fraction	2 (2%)
		Fractional flow reserve	2 (2%)
	Non-enhanced CT	Correlation with other imaging	10 (10%)
		Correlation with patient outcomes	8 (8%)
	Other		4 (4%)

Table 5
The 20 most-cited articles in cardiac CT literature from 2014 to 2015 (Scopus and Web of Science).

Rank	Article	Citations
1	Norgaard BL, Leipsic J, Gaur S, Seneviratne S, Ko BS, Ito H, Jensen JM, Mauri L, De Bruyne B, Bezerra H, Osawa K, Marwan M, Naber C, Erglis A, Park S-J, Christiansen EH, Kaltoft A, Lassen JF, Botker HE, Achenbach S, Grp NXTTS. **Diagnostic Performance of Noninvasive Fractional Flow Reserve Derived From Coronary Computed Tomography Angiography in Suspected Coronary Artery Disease The NXT Trial (Analysis of Coronary Blood Flow Using CT Angiography: Next Steps)**. J Am Coll Cardiol, 2014:1145–55.	128
2	Rochitte CE, George RT, Chen MY, Arbab-Zadeh A, Dewey M, Miller JM, Niinuma H, Yoshioka K, Kitagawa K, Nakamori S, Laham R, Vavere AL, Cerci RJ, Mehra VC, Nomura C, Kofoed KF, Jinzaki M, Kuribayashi S, de Roos A, Laule M, Tan SY, Hoe J, Paul N, Rybicki FJ, Brinker JA, Arai AE, Cox C, Clouse ME, Di Carli MF, Lima JAC. **Computed tomography angiography and perfusion to assess coronary artery stenosis causing perfusion defects by single photon emission computed tomography: the CORE320 study**. Eur Heart J, 2014:1120–30.	81
3	Douglas PS, Hoffmann U, Patel MR, Mark DB, Al-Khalidi HR, Cavanaugh B, Cole J, Dolor RJ, Fordyce CB, Huang M, Khan MA, Kosinski AS, Krucoff MW, Malhotra V, Picard MH, Udelson JE, Velazquez EJ, Yow E, Cooper LS, Lee KL, Investigators P. **Outcomes of Anatomical versus Functional Testing for Coronary Artery Disease**. N Engl J Med, 2015:1291–300.	78
4	Criqui MH, Denenberg JO, Ix JH, McClelland RL, Wassel CL, Rifkin DE, Carr JJ, Budoff MJ, Allison MA. **Calcium Density of Coronary Artery Plaque and Risk of Incident Cardiovascular Events**. JAMA-J Am Med Assoc, 2014:271–8.	59
5	Muhlestein JB, Lappe DL, Lima JAC, Rosen BD, May HT, Knight S, Bluemke DA, Towner SR, Viet L, Bair TL, Vavere AL, Anderson JL. **Effect of Screening for Coronary Artery Disease Using CT Angiography on Mortality and Cardiac Events in High-Risk Patients With Diabetes The FACTOR-64 Randomized Clinical Trial**. JAMA-J Am Med Assoc, 2014:2234–43.	50
6	Bittencourt MS, Hulten E, Ghoshhajra B, O'Leary D, Christman MP, Montana P, Truong QA, Steigner M, Murthy VL, Rybicki FJ, Nasir K, Gowdak LHW, Hainer J, Brady TJ, Di Carli MF, Hoffmann U, Abbara S, Blankstein R. **Prognostic Value of Nonobstructive and Obstructive Coronary Artery Disease Detected by Coronary Computed Tomography Angiography to Identify Cardiovascular Events**. Circ-Cardiovasc Imaging, 2014:282–91.	44
7	Puchner SB, Liu T, Mayrhofer T, Truong QA, Lee H, Fleg JL, Nagurney JT, Udelson JE, Hoffmann U, Ferencik M. **High-Risk Plaque Detected on Coronary CT Angiography Predicts Acute Coronary Syndromes Independent of Significant Stenosis in Acute Chest Pain Results From the ROMICAT-II Trial**. J Am Coll Cardiol, 2014:684–92.	32
8	Meyer M, Haubenreisser H, Schoepf UJ, Vliegenthart R, Leidecker C, Allmendinger T, Lehmann R, Sudarski S, Borggrefe M, Schoenberg SO, Henzler T. **Closing in on the K Edge: Coronary CT Angiography at 100, 80, and 70 kV-Initial Comparison of a Second-versus a Third-Generation Dual-Source CT System**. Radiology, 2014:373–82.	28
9	Fuchs TA, Stehli J, Bull S, Dougoud S, Clerc OF, Herzog BA, Buechel RR, Gaemperli O, Kaufmann PA. **Coronary computed tomography angiography with model-based iterative reconstruction using a radiation exposure similar to chest X-ray examination**. Eur Heart J, 2014:1131–6.	25
10	Rossi A, Dharampal A, Wragg A, Davies LC, van Geuns RJ, Anagnostopoulos C, Klotz E, Kitslaar P, Broersen A, Mathur A, Nieman K, Hunink MGM, de Feyter PJ, Petersen SE, Pugliese F. **Diagnostic performance of hyperaemic myocardial blood flow index obtained by dynamic computed tomography: does it predict functionally significant coronary lesions?** European Heart Journal-Cardiovascular Imaging, 2014:85–94.	25
11	Wong DTL, Ko BS, Cameron JD, Leong DP, Leung MCH, Malaiapan Y, Nerlekar N, Crossett M, Troupis J, Meredith IT, Seneviratne SK. **Comparison of Diagnostic Accuracy of Combined Assessment Using Adenosine Stress Computed Tomography Perfusion plus Computed Tomography Angiography With Transluminal Attenuation Gradient plus Computed Tomography Angiography Against Invasive Fractional Flow Reserve**. J Am Coll Cardiol, 2014:1904–12.	25
12	Kim K-H, Doh J-H, Koo B-K, Min JK, Erglis A, Yang H-M, Park K-W, Lee H-Y, Kang H-J, Kim Y-J, Lee SY, Kim H-S. **A Novel Noninvasive Technology for Treatment Planning Using Virtual Coronary Stenting andComputed Tomography-Derived Computed Fractional Flow Reserve**. JACC-Cardiovasc Interv, 2014:72–8.	24
13	Newby D, Williams M, Hunter A, Pawade T, Shah A, Flapan A, Forbes J, Hargreaves A, Leslie S, Lewis S, McKillop G, McLean S, Reid J, Spratt J, Uren N, Timmis A, Berry C, Boon N, Clark L, Craig P, Barlow T, Flather M, Forbes J, McCormack C, McLean S, Roditi G, van Beek E, Williams M, Hunter A, Shepherd S, Bucukoglu M, Assi V, Parker R, Krishan A, McCormack C, Wee F, Wackett A, Walker A, Milne L, Oatey K, Neary P, Donaldson G, Fairbairn T, Fotheringham M, Hargreaves A, Spratt J, Glen S, Perkins S, Taylor F, Cram L, Beveridge C, Cairns A, Dougherty F, Eteiba H, Rae A, Robb K, Crawford W, Clarkin P, Lennon E, Houston G, Pringle S, Ramkumar PG, Sudarshan T, Fogarty Y, Barrie D, Bissett K, Dawson A, Dundas S, Letham D, O'Neill L, Ritchie V, Weir-McCall J, Dougall H, Ahmed F, Cormack A, Findlay I, Hood S, Murphy C, Peat E, McCabe L, McCubbin M, Allen B, Behan M, Bertram D, Brian D, Cowan A, Cruden N, Denvir M, Dweck M, Flint L, Flapan A, Fyfe S, Grubb N, Keanie C, Lang C, MacGillivray T, MacLachlan D, MacLeod M, Mirsadraee S, Morrison A, Mills N, Northridge D, Phillips A, Queripel L, Reid J, Uren N, Weir N, Jacob A, Bett F, Divers F, Fairley K, Keegan E, White T, Fowler J, Gemmill J, McGowan J, Henry M, Francis M, Sandeman D, Dinnel L, Bloomfield P, Denvir M, Henriksen P, MacLeod D, Morrison A, Berry C, Mangion K, Mordi I, Roditi G, Tzemos N, Connolly E, Boylan H, Brown A, Farrell L, Frood A, Glover C, Johnstone J, Lanaghan K, McGlynn D, McGregor L, McLennan E, Murdoch L, Paterson V, Teyhan F, Teenan M, Woodward R, Steedman T. **CT coronary angiography in patients with suspected angina due to coronary heart disease (SCOT-HEART): an open-label, parallel-group, multicentre trial**. Lancet (London, England), 2015:2383–91.	23
14	Al-Mallah MH, Qureshi W, Lin FY, Achenbach S, Berman DS, Budoff MJ, Callister TQ, Chang H-J, Cademartiri F, Chinnaiyan K, Chow BJW, Cheng VY, DeLago A, Gomez M, Hadamitzky M, Hausleiter J, Kaufmann PA, Leipsic J, Maffei E, Raff G, Shaw LJ, Villines TC, Cury RC, Feuchtner G, Plank F, Kim Y-J, Dunning AM, Min JK. **Does coronary CT angiography improve risk stratification over coronary calcium scoring in symptomatic patients with suspected coronary artery disease? Results from the prospective multicenter international CONFIRM registry.** European Heart Journal-Cardiovascular Imaging, 2014:267–74.	22
15	Park H-B, Heo R, Hartaigh BO, Cho I, Gransar H, Nakazato R, Leipsic J, Mancini GBJ, Koo B-K, Otake H, Budoff MJ, Berman DS, Erglis A, Chang H-J, Min JK. **Atherosclerotic Plaque Characteristics by CT Angiography Identify Coronary Lesions That Cause Ischemia**. JACC-Cardiovasc Imag, 2015:1–10.	22
16	George RT, Mehra VC, Chen MY, Kitagawa K, Arbab-Zadeh A, Miller JM, Matheson MB, Vavere AL, Kofoed KF, Rochitte CE, Dewey M, Yaw TS, Niinuma H, Brenner W, Cox C, Clouse ME, Lima JAC, Di Carli M. **Myocardial CT Perfusion Imaging and SPECT for the Diagnosis of Coronary Artery Disease: A Head-to-Head Comparison from the CORE320 Multicenter Diagnostic Performance Study**. Radiology, 2014:407–16.	20
17	Stuijfzand WJ, Danad I, Raijmakers PG, Marcu CB, Heymans MW, van Kuijk CC, van Rossum AC, Nieman K, Min JK, Leipsic J, van Royen N, Knaapen P. **Additional Value of Transluminal Attenuation Gradient in CT Angiography to Predict Hemodynamic Significance of Coronary Artery Stenosis**. JACC-Cardiovasc Imag, 2014:374–86.	20
18	Min JK, Labounty TM, Gomez MJ, Achenbach S, Al-Mallah M, Budoff MJ, Cademartiri F, Callister TQ, Chang H-J, Cheng V, Chinnaiyan KM, Chowk B, Cury R, Delago A, Dunning A, Feuchtner G, Hadamitzky M, Hausleiter J, Kaufmann P, Kim Y-J, Leipsic J, Lin FY, Maffei E, Raff G, Shaw LJ, Villines TC, Berman DS. **Incremental prognostic value of coronary computed tomographic angiography over coronary artery calcium score for risk prediction of major adverse cardiac events in asymptomatic diabetic individuals**. Atherosclerosis, 2014:298–304.	18
19	Motoyama S, Ito H, Sarai M, Kondo T, Kawai H, Nagahara Y, Harigaya H, Kan S, Anno H, Takahashi H, Naruse H, Ishii J, Hecht H, Shaw LJ, Ozaki Y, Narula J. **Plaque Characterization by Coronary Computed Tomography Angiography and the Likelihood of Acute Coronary Events in Mid-Term Follow-Up**. J Am Coll Cardiol, 2015:337–46.	16
20	Yuki H, Utsunomiya D, Funama Y, Tokuyasu S, Namimoto T, Hirai T, Itatani R, Katahira K, Oshima S, Yamashita Y. **Value of knowledge-based iterative model reconstruction in low-kV 256-slice coronary CT angiography**. J Cardiovasc Comput Tomogr, 2014:115–23.	12

not had time to accumulate citations. In order to correct for this, a search was performed using the same terms in the original analysis of 100 articles, but using a shorter time period (2014 and 2015). The top 20 most-cited articles from 2014 to 2015 are listed in Table 5.

3.9. Non-original articles

In order to capture the most-cited non-original articles, a search was performed using the same search terms in the original analysis of 100 articles, but selecting for guidelines and reviews. The top 10 review and guideline articles are shown in Table 6.

4. Discussion

The most-cited article in our list of the 100 most-cited articles in cardiac CT was "Quantification of coronary artery calcium using ultrafast computed tomography" by Agatston et al., 1990 in the Journal of the American College of Cardiology. This article also had the highest number of citations per year. The Journal of the American College of Cardiology published the greatest number of articles from the 100 most-cited article list with 34. The next largest contributors were the journals Circulation and Radiology with 17 and 13, respectively.

The majority of the 100 most-cited articles pertained to calcium volume with unenhanced CT, or coronary artery patency with enhanced CT. Prospective studies of coronary CT angiography (coronary CTA) diagnostic accuracy using conventional or quantitative coronary angiography as a gold standard comparator was the most common study topic (35%).

One limitation of this citation-based searching method is that it does not capture prominent recent articles that have not yet had time to accumulate citations. For example, the SCOT-HEART and NXT trials, though prominent studies, were not captured due to their recent publication and resulting low citation count. We

Table 6
Top 10 most-cited review and guideline articles in cardiac CT literature.

Rank	Article	Citations
1	Naghavi M, Libby P, Falk E, Casscells SW, Litovsky S, Rumberger J, Badimon JJ, Stefanadis C, Moreno P, Pasterkamp G, Fayad Z, Stone PH, Waxman S, Raggi P, Madjid M, Zarrabi A, Burke A, Yuan C, Fitzgerald PJ, Siscovick DS, de Korte CL, Aikawa M, Juhani Airaksinen KE, Assmann G, Becker CR, Chesebro JH, Farb A, Galis ZS, Jackson C, Jang IK, Koenig W, Lodder RA, March K, Demirovic J, Navab M, Priori SG, Rekhter MD, Bahr R, Grundy SM, Mehran R, Colombo A, Boerwinkle E, Ballantyne C, Insull W, Jr., Schwartz RS, Vogel R, Serruys PW, Hansson GK, Faxon DP, Kaul S, Drexler H, Greenland P, Muller JE, Virmani R, Ridker PM, Zipes DP, Shah PK, Willerson JT. **From vulnerable plaque to vulnerable patient: a call for new definitions and risk assessment strategies: Part I**. Circulation, 2003:1664–72.	1062
2	Naghavi M, Libby P, Falk E, Casscells SW, Litovsky S, Rumberger J, Badimon JJ, Stefanadis C, Moreno P, Pasterkamp G, Fayad Z, Stone PH, Waxman S, Raggi P, Madjid M, Zarrabi A, Burke A, Yuan C, Fitzgerald PJ, Siscovick DS, de Korte CL, Aikawa M, Airaksinen KE, Assmann G, Becker CR, Chesebro JH, Farb A, Galis ZS, Jackson C, Jang IK, Koenig W, Lodder RA, March K, Demirovic J, Navab M, Priori SG, Rekhter MD, Bahr R, Grundy SM, Mehran R, Colombo A, Boerwinkle E, Ballantyne C, Insull W, Jr., Schwartz RS, Vogel R, Serruys PW, Hansson GK, Faxon DP, Kaul S, Drexler H, Greenland P, Muller JE, Virmani R, Ridker PM, Zipes DP, Shah PK, Willerson JT. **From vulnerable plaque to vulnerable patient: a call for new definitions and risk assessment strategies: Part II**. Circulation, 2003:1772–8.	1020
3	Budoff MJ, Achenbach S, Blumenthal RS, Carr JJ, Goldin JG, Greenland P, Guerci AD, Lima JA, Rader DJ, Rubin GD, Shaw LJ, Wiegers SE. **Assessment of coronary artery disease by cardiac computed tomography: a scientific statement from the American Heart Association Committee on Cardiovascular Imaging and Intervention, Council on Cardiovascular Radiology and Intervention, and Committee on Cardiac Imaging, Council on Clinical Cardiology**. Circulation, 2006:1761–91.	894
4	Hendel RC, Patel MR, Kramer CM, Poon M, Hendel RC, Carr JC, Gerstad NA, Gillam LD, Hodgson JM, Kim RJ, Kramer CM, Lesser JR, Martin ET, Messer JV, Redberg RF, Rubin GD, Rumsfeld JS, Taylor AJ, Weigold WG, Woodard PK, Brindis RG, Hendel RC, Douglas PS, Peterson ED, Wolk MJ, Allen JM, Patel MR. **ACCF/ACR/SCCT/SCMR/ASNC/NASCI/SCAI/SIR 2006 appropriateness criteria for cardiac computed tomography and cardiac magnetic resonance imaging: a report of the American College of Cardiology Foundation Quality Strategic Directions Committee Appropriateness Criteria Working Group, American College of Radiology, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, American Society of Nuclear Cardiology, North American Society for Cardiac Imaging, Society for Cardiovascular Angiography and Interventions, and Society of Interventional Radiology**. J Am Coll Cardiol, 2006:1475–97.	869
5	Greenland P, Bonow RO, Brundage BH, Budoff MJ, Eisenberg MJ, Grundy SM, Lauer MS, Post WS, Raggi P, Redberg RF, Rodgers GP, Shaw LJ, Taylor AJ, Weintraub WS. **ACCF/AHA 2007 clinical expert consensus document on coronary artery calcium scoring by computed tomography in global cardiovascular risk assessment and in evaluation of patients with chest pain: a report of the American College of Cardiology Foundation Clinical Expert Consensus Task Force (ACCF/AHA Writing Committee to Update the 2000 Expert Consensus Document on Electron Beam Computed Tomography) developed in collaboration with the Society of Atherosclerosis Imaging and Prevention and the Society of Cardiovascular Computed Tomography**. J Am Coll Cardiol, 2007:378–402.	540
6	Taylor AJ, Cerqueira M, Hodgson JM, Mark D, Min J, O'Gara P, Rubin GD, Kramer CM, Berman D, Brown A, Chaudhry FA, Cury RC, Desai MY, Einstein AJ, Gomes AS, Harrington R, Hoffmann U, Khare R, Lesser J, McGann C, Rosenberg A, Schwartz R, Shelton M, Smetana GW, Smith SC, Jr. **ACCF/SCCT/ACR/AHA/ASE/ASNC/NASCI/SCAI/SCMR 2010 appropriate use criteria for cardiac computed tomography. A report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the Society of Cardiovascular Computed Tomography, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the American Society of Nuclear Cardiology, the North American Society for Cardiovascular Imaging, the Society for Cardiovascular Angiography and Interventions, and the Society for Cardiovascular Magnetic Resonance**. J Am Coll Cardiol, 2010:1864–94.	464
7	Naghavi M, Falk E, Hecht HS, Jamieson MJ, Kaul S, Berman D, Fayad Z, Budoff MJ, Rumberger J, Naqvi TZ, Shaw LJ, Faergeman O, Cohn J, Bahr R, Koenig W, Demirovic J, Arking D, Herrera VL, Badimon J, Goldstein JA, Rudy Y, Airaksinen J, Schwartz RS, Riley WA, Mendes RA, Douglas P, Shah PK. **From vulnerable plaque to vulnerable patient–Part III: Executive summary of the Screening for Heart Attack Prevention and Education (SHAPE) Task Force report**. Am J Cardiol, 2006:2h–15h.	392
8	Schroeder S, Achenbach S, Bengel F, Burgstahler C, Cademartiri F, de Feyter P, George R, Kaufmann P, Kopp AF, Knuuti J, Ropers D, Schuijf J, Tops LF, Bax JJ. **Cardiac computed tomography: indications, applications, limitations, and training requirements: report of a Writing Group deployed by the Working Group Nuclear Cardiology and Cardiac CT of the European Society of Cardiology and the European Council of Nuclear Cardiology**. Eur Heart J, 2008:531–56.	356
9	Raff GL, Abidov A, Achenbach S, Berman DS, Boxt LM, Budoff MJ, Cheng V, DeFrance T, Hellinger JC, Karlsberg RP. **SCCT guidelines for the interpretation and reporting of coronary computed tomographic angiography**. J Cardiovasc Comput Tomogr, 2009:122–36.	332
10	Greenland P, Bonow RO, Brundage BH, Budoff MJ, Eisenberg MJ, Grundy SM, Lauer MS, Post WS, Raggi P, Redberg RF, Rodgers GP, Shaw LJ, Taylor AJ, Weintraub WS. **ACCF/AHA 2007 clinical expert consensus document on coronary artery calcium scoring by computed tomography in global cardiovascular risk assessment and in evaluation of patients with chest pain: a report of the American College of Cardiology Foundation Clinical Expert Consensus Task Force (ACCF/AHA Writing Committee to Update the 2000 Expert Consensus Document on Electron Beam Computed Tomography) developed in collaboration with the Society of Atherosclerosis Imaging and Prevention and the Society of Cardiovascular Computed Tomography**. J Am Coll Cardiol, 2007:378–402.	328

attempted to compensate for this limitation by using the same search terms as the original analysis, but restricting the search to 2014 and 2015, in order to identify the top 20 most-cited articles. Included in these top 20 articles are the SCOT-HEART and NXT trials.

5. Conclusion

Reviewing the 100 most-cited articles in cardiac CT and examining the citations-per-year allows clinicians and researchers to rapidly identify the most influential literature and understand the trajectory of cardiac CT imaging research over time. A more in depth review of these articles reveals the characteristics of highly cited works. This provides authors with insight into factors which contribute to highly cited papers and helps guide further research into the future.

Conflicts of interest

None.

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