Investigating the level of agreement in the measurement of coronary artery calcification among radiology technicians and radiology specialists

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Background: To investigate the level of agreement in the measurement of coronary artery calcification among radiology technicians and radiology specialists. **Materials and Methods:** This cross-sectional study was conducted on 544 cases in the Radiology Department of Al-Zahra Hospital in Isfahan in 2021. The archives of heart computed tomography scans were reviewed, and coronary artery calcium scores (CACS) reported by radiology technicians and radiologists were marked and compared. **Results:** The level of agreement of the score measured by two evaluators in the whole sample is equal to intracluster correlation coefficient = 0.996 (95% confidence interval [CI]: 0.995−0.997) ($P < 0.001$) and the level of agreement based on calcification categories measured by weighted kappa was 0.968 (95% CI: 0.953−0.982)($P < 0.001$), both of which indicate an excellent and significant intensity of agreement. **Conclusion:** The results of our study demonstrate a high level of agreement regarding CACS between technicians and radiologists.

Key words: Coronary artery calcification, coronary artery calcium scores, radiologist, technician

INTRODUCTION

As we know, the increase in coronary artery calcium scores (CACS) is directly related to cardiovascular diseases, and accurate measurement of this calcium has a special place due to its importance in prevention and treatment.[1,2] Considering the various results in studies that examined the agreement between technicians and radiology experts in various fields,[3] we decided to check the level of agreement between technicians and radiology specialists and, as a result, the accuracy of this measurement by technicians.

METHODS

In this study, the researcher referred to the archives of the Cardiac Imaging Department in the Radiology Center of Al-Zahra Hospital in Isfahan province during the years 2020–2021 to check for CACS and their reports. The study was approved by the Institutional Review Board in Isfahan University of Medical Sciences (code: IR.MUI.MED.REC.1403.238).

The coronary arteries were examined by the registered radiology technicians. In all cases, the measurement and marker of coronary artery calcification were repeated by a radiologist. Therefore, two numbers were recorded, CS based on the technologist's measurements and the radiologist's measurements. All cases were scanned by a multidetector computed tomography scan (Siemens 128 slice, Germany) and a special workstation for reporting. For imaging, the thickness of the slices was 2.5 mm, and the tube voltage was 120 KV. In CS by the Agatston

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method, the calcification points that have a density higher than 130 HU are subjected to scoring.[4] For this purpose, the software on the device displays the eligible points in color, and the radiologist/technologist must distinguish the points that are related to the course of the coronary arteries (rather than the calcification of other structures). Then, the software obtains the score of each point and the overall score through the area by a fixed number (based on density). The constant number for density 199–130 HU is equal to 1, for density 200–299 HU is equal to 2, for density 300–399 HU is equal to 3, and for density 400 HU and above, this number is equal to 4.[5]

RESULTS

The present study was conducted on 544 cases. Table 1 shows the distribution of demographic variables and radiological characteristics and the performance results of radiologists and technicians in evaluating CSs in the entire sample and the CAD-RADS levels.

Tables 2 and 3 show the distribution of calcification scores evaluated in patients by radiologists and technicians. The radiologist evaluated 52, 205, 137, and 150 patients in categories 1–4, respectively, and similarly, the technician evaluated 58, 202, 136, and 148, respectively. Distribution of demographic variables, CS evaluated by radiologist and technician, and radiological characteristics of region of interest (ROI), area, volume, and mass are also reported in Tables 2 and 3. The average age in the intensity of evaluated calcification by both evaluators shows a significant difference as seen; the average age increases significantly with the increase in the intensity of calcification ($P < 0.001$. In both technicians and specialists evaluations, men compared to women are seen in higher calcification intensities – 3 and 4; hence, a significant gender difference in calcification intensity can be seen ($P < 0.05$). The average CS measured by the radiologist and the technician shows a significant difference across the categories of intensity of evaluated calcification by these two evaluators, and the average CS increases significantly by increasing calcification categories ($P > 0.001$). The average radiological indicators of ROI, area, volume, and mass in the intensity of calcification evaluated by both evaluators show a significant difference ($P < 0.001$) [Tables 2 and 3].

Table 4 shows the degree of agreement between the radiologist and the technician in scoring based on the intracluster correlation coefficient (ICC) and Cohen's kappa indicators in the entire sample and each of the CAD-RADS categories. The level of agreement of the score measured by two evaluators in the whole sample is equal to intracluster correlation coefficient = 0.996 (95% confidence interval [CI]: 0.995–0.997) ($P < 0.001$) and the level of agreement based on calcification categories measured by weighted kappa = 0.968 (95% CI: 0.953–0.982) ($P < 0.001$), both of which

Table 1: Comparison of demographic and radiological characteristics and performance of radiologists and technicians in CAD-RADS categories

Variables	Total (544)	CAD-RADS grades							P
		1 (130)	2 (124)	3 (73)	4 (23)	4A (124)	4B (26)	5 (44)	
Age	62.65±10.03	59.88±10.23	10.23±9.25	63.86±9.80	64.52±7.97	64.59±9.76	64.23±11.75	65.23±10.63	0.001
Sex, *n* (%)									
Male	291 (53.5)	58 (44.6)	60 (48.4)	39 (53.4)	13 (56.5)	77 (62.1)	13 (50)	31 (70.5)	0.025
Female	253 (46.5)	72 (55.4)	64 (51.6)	34 (46.6)	10 (43.5)	47 (37.9)	13 (50)	13 (29.5)	
Calcium score measured by technician	402.08±691.70	34.35±49.99	174.45±345.79	292.39±294.50	102.69±115.43	705.20±790.83	1238.38±1046.43	1120.09±1128.11	<0.001
Calcium score measured by radiologist	416.56±714.06	38.88±62.95	180.64±356.17	293.23±301.83	102.74±115.31	718.66±799.33	1373.23±1129.46	1149.22±1139.81	<0.001
ROI	19.44±22.72	5.48±5.42	11.14±12.97	17.69±14.77	8.65±5.93	30.39±21.98	53.57±38.04	41.54±30.60	<0.001
Area	145.01±273.28	16.52±22.92	65.32±118.86	104.85±103.82	39.04±39.15	260.85±400.98	408.96±320.48	388.79±379.47	<0.001
Volume	356.26±584.49	41.43±57.407	162.18±297.54	262.46±259.90	97.83±98.13	599.11±628.11	1147.46±935.19	972.23±948.79	<0.001
Mass	83,097±148,057	8.25±14.34	36.07±70.91	57.52±57.96	20.09±22.30	144.50±166.36	281.35±262.30	232.75±233.68	<0.001

ROI=Region of interest

Table 2: Distribution of demographic variables, calcium score, and radiological characteristics at calcification severity assessed by radiologist

Variables	Classification levels assessed by radiologist				
	1 (52)	2 (205)	3 (137)	4 (150)	*P*
Age	56.33±9.69	60.76±9.36	62.93±9.52	67.17±9.61	<0.001
Sex, *n* (%)					
Male	20 (38.5)	101 (49.3)	84 (61.3)	86 (57.3)	0.015
Female	32 (61.5)	104 (50.7)	53 (38.7)	64 (42.7)	
Technician	5.00±2.76	45.91±25.71	212.98±86.90	1199.22±913.06	<0.001
Radiologist	5.15±2.31	47.50±24.84	216.68±87.10	1246.11±935.09	<0.001
ROI	3.34±1.84	6.15±3.67	16.01±8.64	46.31±26.88	<0.001
Area	4.36±1.86	20.14±9.94	104.60±311.85	401.33±295.40	<0.001
Volume	10.8654±4.52023	50.5951±24.62278	198.7372±79.70592	1037.63±760.26	<0.001
Mass	1.58±0.66	9.60±4.91	42.72±17.75	251.85±200.51	<0.001

ROI=Region of interest

Table 3: Distribution of demographic variables, Calcium score, and radiological characteristics at calcification severity assessed by technician

Variable	Classification levels assessed by technician				
	1 (58)	2 (202)	3 (136)	4 (148)	*P*
Age	56.72±9.54	60.66±9.36	63.54±9.77	66.87±9.52	<0.001
Sex, *n* (%)					
Male	25 (43.1)	97 (48)	84 (61.8)	85 (57.4)	0.022
Female	33 (56.9)	105 (52)	52 (38.2)	63 (42.6)	
Technician	5.12±2.69	47.52±25.18	214.59±1883.68	1213.86±910.56	<0.001
Radiologist	8.34±11.82	49.28±26.26	227.39±122.99	1251.65±939.25	<0.001
ROI	3.91±2.97	6.35±4.67	16.18±8.85	46.38±27.02	<0.001
Area	5.83±5.41	20.67±10.44	82.12±42.23	427.06±401.78	<0.001
Volume	14.57±13.64	51.91±25.87	207.78±106.13	1042.02±763.81	<0.001
Mass	2.32±2.58	9.83±5.09	45.13±25.53	252.85±201.51	<0.001

ROI=Region of interest

Table 4: The agreement in the assessment of the calcium score and classification levels between the radiologist and the technician in the entire sample and in the CAD-RADS categories

Agreement measure	Total sample	CAD-RADS categories							*P*
		1	2	3	4	4A	4B	5	
ICC (95% CI)	0.996 (0.995–0.997)	0.931 (0.902–0.951)	0.998 (0.997–0.998)	0.994 (0.990–0.996)	1 (0.999–1)	0.999 (0.998–0.999)	0.979 (0.946–0.991)	0.996 (0.993–0.998)	<0.001 for all
Weighted kappa (95% CI)	0.968 (0.953–0.982)*	0.915 (0.85–0.98)	0.932 (0.879–0.985)	0.985 (0.954–1)	1 (1–1)	0.948 (0.905–0.992)	0.93 (0.788–1)	1 (1–1)	<0.001 for all

*P values less than 0.05 were considered significant. ICC=Intracluster correlation coefficient; CI=Confidence interval

indicate an excellent and significant intensity of agreement. The assessment of the intensity of agreement between the measurement of both the CS index and the intensity of calcification in CAD-RADS categories was also at an excellent level and statistically significant with $P < 0.001$. Evaluation of CS agreement by radiologist and technician was done visually with the Bland–Altman diagram, which is shown in Figure 1, and this diagram also shows the excellent agreement obtained with the ICC index.

DISCUSSION

Our data showed significant agreement regarding CACS between technicians and radiologists. As it is clear in the Bland–Altman diagram, there are a number of outlier data which are actually the few cases where there was a significant difference between the CS calculation between the radiologist and the technician. These cases were specifically examined in terms of the areas selected by the technician as calcifications in the coronary arteries. In total, calcification in the pericardium, mitral valve, and sinus of Valsalva were mistakenly chosen by the technicians as calcification in the coronary arteries, although the total amount was very low and not statistically significant. It should be noted that for many years, in our center, we have talked with the technician and given feedback to them on every case that seems to have a clear difference between the CS calculation between the radiologist and the technician,
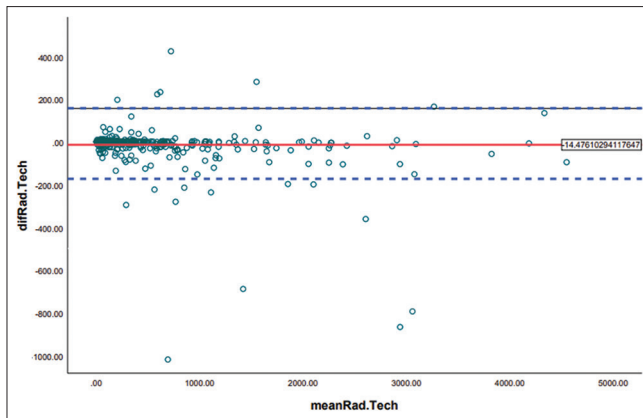
Figure 1: Evaluation of the agreement of the measurements obtained by the radiologist and the technician from the calcium score index by the Bland–Altman diagram

and the results of the recent study are the effect of this interaction and training to the technicians of our center.

CONCLUSION

The results of our study demonstrate that technicians and radiologists agree on CACS.

Authors' contributions
Awat feizi - Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work. Fateme Sadat Mostafavi - Drafting the work or revising it critically for important intellectual content. Maryam moradi - Final approval of the version to be published. Ebrahim Rafiei - Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflicts of interest
There are no conflicts of interest.

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