

Calcium Scoring with AIDR 3D

Introduction

- The original research defining Agatston Score was performed with EBCT (Electron Beam CT)
- To replicate these results the closest technique on current CT scanners is:
 - 120kV, 300mA, 3mm slices, FC12
- This protocol does not take advantage of all the dose saving techniques available on CT scanners today including:
 - Volume scan
 - SUREExposure
 - AIDR 3D
 - FIRST
- The current default Ca Score protocol on Aquilion ONE Genesis and Prime SP is:
 - Volume scan/Wide Volume scan (0.5mm Slice thickness)
 - SUREExposure: SD 60, Max mA 370, Min mA 40
 - FC12
 - 3mm reconstructed slice thickness, 3mm interval

Introduction

- The default Ca Score protocol generally provides radiation doses that are higher than the CTA scan.
- Therefore some sites have stopped performing Ca Score scans.

- A number of sites have investigated the accuracy of Agatston Scores with AIDR 3D
- Based on these results we can now recommend AIDR 3D for Calcium scoring

- This will reduce the dose for Calcium Scoring examinations to same or less than the CTA.

Scientific Evidence – Review Article

Curr Cardiovasc Imaging Rep (2016) 9: 12
DOI 10.1007/s12410-016-9373-1



CARDIAC COMPUTED TOMOGRAPHY (TC VILLINES, SECTION EDITOR)

Low Radiation Dose Calcium Scoring: Evidence and Techniques

Kaitlin B. Baron¹ • Andrew D. Choi^{1,2} • Marcus Y. Chen²

In conclusion, we now have an increasing body of evidence on multiple platforms that CAC scoring at sub-mSv radiation doses can be performed reliably, particularly through the use of iterative reconstruction.

Scientific Evidence – Review Article

The impact of dose reduction on the quantification of coronary artery calcifications and risk categorization: A systematic review

Marleen Vonder^{a,*}, Niels R. van der Werf^b, Tim Leiner^b, Marcel J.W. Greuter^c,
Dominik Fleischmann^d, Rozemarijn Vliegenthart^a, Matthijs Oudkerk^a, Martin J. Willemink^{b,d}

JCCT, 2018, DOI:10.1016/j.jcct.2018.06.001

The impact of AIDR 3D and tube current reduction was examined in five studies, including two phantoms and 441 patients.

Radiation doses of the full dose protocols ranged from 4.1 to 16.1 mGy and reduced to radiation doses ranging from 0.7 to 5.7 mGy with a reclassification of 5%–11% when AIDR 3D was used.

Scientific Evidence

Prospective evaluation of the influence of iterative reconstruction on the reproducibility of coronary calcium quantification in reduced radiation dose 320 detector row CT

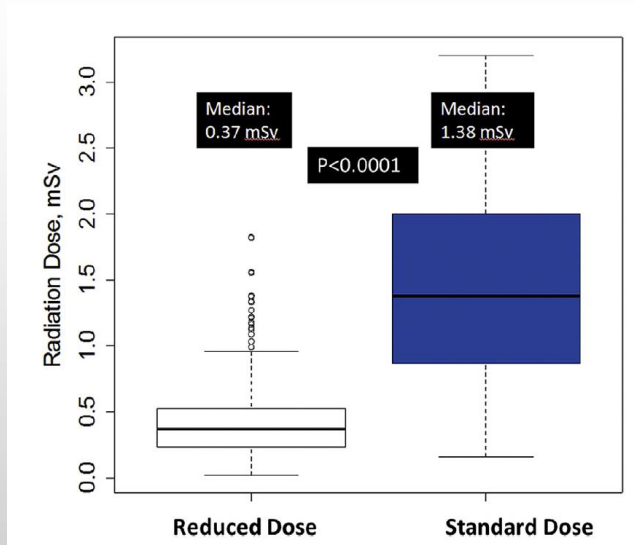
Andrew D. Choi ^{a, c}, Eric S. Leifer ^b, Jeannie Yu ^a, Sujata M. Shanbhag ^a, Kathie Bronson ^a, Andrew E. Arai ^a, Marcus Y. Chen ^{a, *}

Journal of Cardiovascular Computed Tomography 10 (2016) 359e363

Reduced-dose image acquisition in combination with iterative reconstruction, when compared to standard-dose image acquisition with filtered back projection, achieves a median radiation dose of 0.37 mSv, resulting in comparable image quality, rescan agreement and risk classification while providing 74% radiation dose reduction.

Scientific Evidence

Radiation Dose



Agreement Standard Dose vs Low Dose

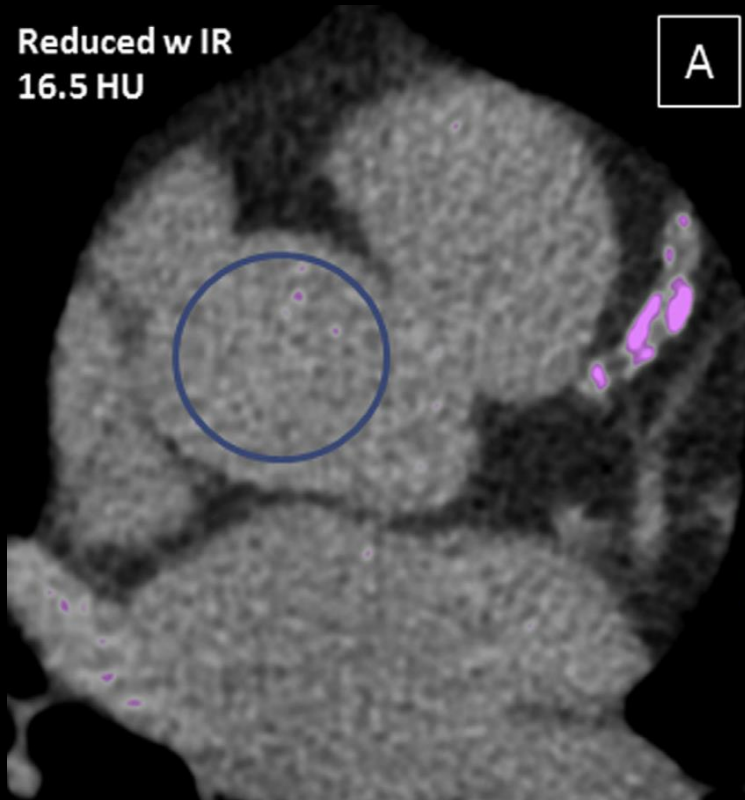
		Standard w FBP				
		0	1-10	11-100	101-400	>400
Reduced w IR	0	291	21	0	0	0
	1-10	17	46	11	0	0
	11-100	2	5	91	8	0
	101-400	0	0	8	146	12
	>400	0	0	0	2	140

Overall Agreement = 89%, (95% CI: 86%-92%)
 $k = 0.86$ (95% CI: 0.81 – 0.90)

200 patients scanned 4 times (2x standard dose and 2x low dose)
 74% Dose reduction

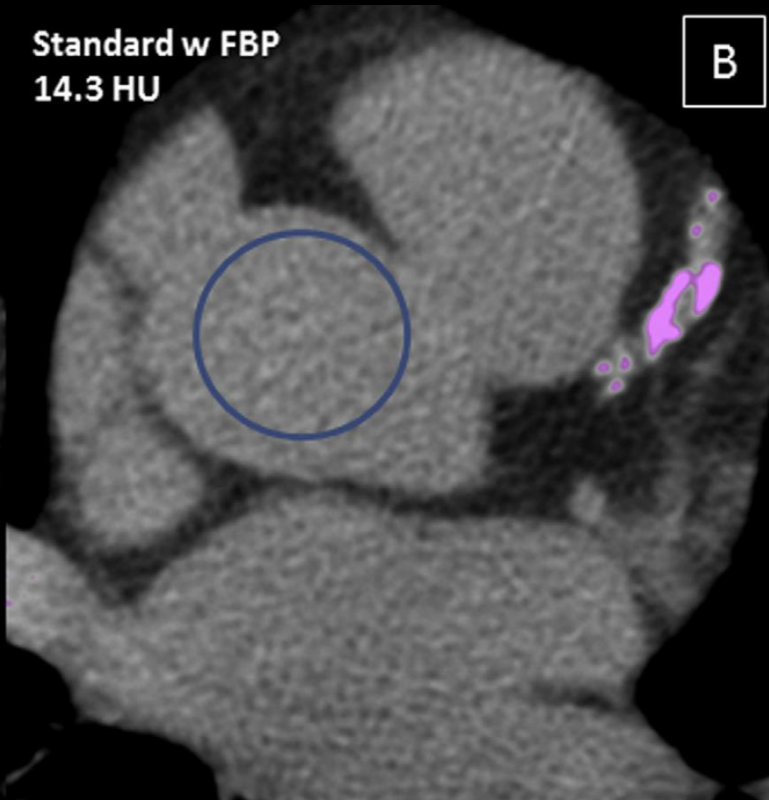
Clinical Example

Reduced w IR
16.5 HU



A

Standard w FBP
14.3 HU



B

Scientific Evidence

Accuracy of coronary artery calcium scoring with tube current reduction by 75%, using an adaptive iterative reconstruction algorithm

¹RENY LUHUR, MD, ²JOANNE D SCHUIJF, PhD, ²JÜRGEN MEWS, Dipl.-Ing., ²JÖRG BLOBEL, PhD, ¹BERND HAMM, MD and ¹ALEXANDER LEMBCKE, MD

Br J Radiol. 2018 Apr;91(1084):20170678. doi: 10.1259/bjr.20170678

The application of IR by means of AIDR 3D standard allows one to maintain accurate Agatston scores and cardiovascular risk stratification when the tube current is reduced by 75%, thus substantially decreasing the patient's exposure to ionizing radiation.

Scientific Evidence

B		IR reduced dose						
		0	1-10	11-100	101-400	401-1000	>1000	Total
FBP standard dose	0	47	-	-	-	-	-	47
	1-10	-	7	-	-	-	-	7
	11-100	-	-	48	2	-	-	50
	101-400	-	-	3	33	-	-	36
	400-1000	-	-	-	2	16	1	19
	>1000	-	-	-	-	-	4	4
	Total	47	7	51	37	16	5	163

163 patients scanned two times (1 Standard, 1 low dose)
75% dose reduction

Scientific Evidence

Adaptive Iterative Dose Reduction 3D Integrated with Automatic Tube Current Modulation for CT Coronary Artery Calcium Quantification: Comparison to Traditional Filtered Back Projection in an Anthropomorphic Phantom and Patients

Ya-Chun Tang, Bsc, Yuan-Chang Liu, MD, Ming-Yi Hsu, MD, Hui-Yu Tsai, PhD¹,
Chien-Ming Chen, MD

Acad Radiol 2018; 25:1010–1017

The absolute Agatston score differed between FBP and AIDR3D reconstructions. However, the cardiac risk categorizations of the two methods were comparable. An integrated AIDR 3D algorithm with automatic tube current modulation enables radiation dose savings at a consistent noise level without sacrificing CACS

Scientific Evidence

	Reconstruction Algorithm		P Value
	FBP	AIDR 3D	
Agatston score	258 (139, 896)	226 (138, 993)	.06
Volume score	271 (123, 796)	268 (117, 783)	.09
Agatston score risk category (0/1/2/3/4)	4 (0/3/2/9/10)	4 (0/4/1/9/10)	.92
Agatston score percentile-based risk category (1/2/3/4/5/6)	6 (0/0/2/5/7/10)	6 (0/0/2/5/7/10)	1
Image noise (HU)	16.5 ± 4.1	16.9 ± 1.9	.63
SSDE (mGy)	13.9 ± 1.2	5.7 ± 2.2	<.01
Effective dose (mSV)	2.1 ± 0.3	0.9 ± 0.4	<.01

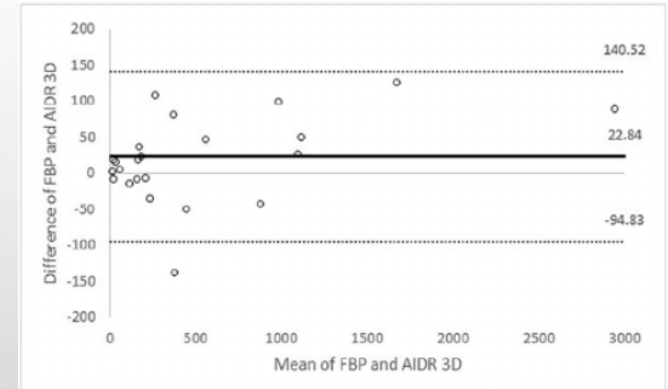


Figure 6. Bland-Altman plots of Agatston scores for patient cohort (mean difference 22.8, upper limit 140.1, lower limit -94.8). AIDR, adaptive iterative dose reduction; FBP, filtered back projection.

24 patients scanned two times (1 standard, 1 low dose)
57.8% dose reduction

Scientific Evidence - Summary

	Number of Patients	Radiation Dose Standard Scan (mSv)	Radiation Dose Low Dose Scan (mSv)	Dose Reduction (%)	Agatston Category Reclassification
Choi, et al (2016)	200	1.4	0.37	74%	11%
Luhur, et al (2017)	163	1.77	0.44	75%	4.9%
Tang, et al (2018)	24	2.1	0.9	57%	8%

k=0.014

Choi, et al, Journal of Cardiovascular Computed Tomography 10 (2016) 359e363
Luhur R, et al, Br J Radiol. 2018 Apr;91(1084):20170678. doi: 10.1259/bjr.20170678
Tang YC, et al, Acad Radiol 2018; 25:1010–1017

Recommended Protocol

SUREIQ

SureIQ Set

☐ TOSHIBA Protocol

New Delete ▲ ▼

Spine
Bone
St Tissue
CTA
Cardiac
Pediatric
Service
Scano

New Delete ▲ ▼

Myocardium
Stent
Low Dose
Ca Score
Ca Score ADR

Recon Settings

Recon FC: FC12 BOOST OFF

Hybrid OFF OSR Cardiac

Recon Process: ADR 3D

Filter: ☐ Image Filter OFF

WW1 400 WL1 40
WW2 1500 WL2 -500
WW3 380 WL3 40

Save Quit

SUREExposure

Sure Exp. 3D Set

☐ TOSHIBA Protocol

New Delete ▲ ▼

CTA Quality
CTA Standard
CTA Low Dose
Ca Score
Ca Score ADR 3D

SureIQ Cardiac Ca Score...

FC: 12
BOOST: OFF
Recon Process: eStandard
Image Filter: OFF
OSR: Cardiac

SD 60.00 MAX 370 mA MIN 40 mA

Image Thickness 0.5 mm

Save Quit

Recommended Protocol

➤ Scan Protocol

☒ Scan Sequence ☐ Time Sequence

Protocol Scan Details Recon. Details Dose Contrast

No. SureCardio (Volume)

1

Target Auto



Ave. HR : 60
HR Tolerance : 57 -64

2

Heart rate (bpm)

60

Breath hold time

10.0

Target Phase

75 %

3

Breath Ex.

Time resolution

137.50 ms

Exposure Window

275ms

Heart rate acq

Detail

Beat

1(Half)

Thickness

0.5

W-Volume

OFF

Sure Exp. 3D
Ca Score A...

kV

120

mA

RP ***

Rot. Time

0.275

Range

120.0

D-FOV

199.2 (L)

Eff. mAs

Total ScanTime

1.176

Direction

OUT

CE

OFF

Focus

Small

Comment

CACS

Exp. Detail

Expected
Exp. Time

0.28

Max.
Exp. Time

99.0

Copy

New Scan

Delete

BreathControl

Recommended Protocol

➤ Reconstruction Protocol

☒ Scan Sequence

☐ Time Sequence

No.	Start	Start Time	Wait	Start Pos.	End Pos.	Scan Mode
1	P	***	***	0.0	500.0	DualScano
2	A	***	***	500.0	0.0	DualScano
3	P		0.0	0.0	120.0	Volume

Protocol

Scan Details

Recon. Details

Dose

Contrast

Volume1

Multi View1

Volume2

Multi View2

Volume3

Multi View3

☒ ON ☐ OFF

Detail

Cardiac Ca Score ...

Gating ON

Transfer OFF

Slice Thickness

0.5

Xact+

ON

Cardiac Phase

☒ CTA ☐ CFA ☐ PhaseXact

75

% ☐

Slice Interval

0.5

F/H

HALF

SEMAR

OFF

Application Type

CaScore

Series Description

of volume(s)

1

Copy

New Scan

Delete

BreathControl

➤ Reconstruction Protocol

Canon

Further Research

- Further research is underway to investigate the effect on Agatston Scores of
 - 100kV
 - FIRST
 - DLR (AiCE)

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