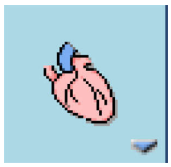
11 Calcium Scoring



The (Cardiac) Calcium Scoring (CS) option is used to estimate the amount of calcium in the coronary arteries or other organs. This is achieved by performing automatic calculations on CT numbers inside Regions of Interest (ROIs), which the operator places around selected areas within a sequence of images.

NOTICE

Before continuing, refer to the “Instructions for Use” that came with your scanner.

The (Cardiac) Calcium Scoring application accepts gated and non-gated images in DICOM format from any vendor, however, only Philips images access the Score database.

WARNING

When loading images into Cardiac Calcium Scoring, all images which contain 16 bit data are converted into 12 bit images. This means that for rescale intercept equal to -1000, HU values above 3095 are displayed as 3095. For rescale intercept equal to -1024, HU values above 3071 are displayed as 3071.

/881 * 2021-06-30

Load Multiple Studies in Application

To load multiple studies in the application:

1. Use the **Ctrl** key when selecting studies from the Directory list.
2. Select the application from the Applications menu.
3. Confirm the studies are from the same patient.

NOTICE

Depending on your Portal configuration, this application may not be available.

Indications for Use

CT Calcium Scoring is a post-processing application designed to assist in the quantification of high-density structures such as calcified lesions in the cardio-thoracic region.

Philips

Cardiac Calcium Scoring Algorithm

The Cardiac Score of each ROI in each image depends on the Area of CT values greater than the threshold and on the density of CT values in that region. A total score is calculated for the selected sequence of images by selecting a preset, or user-defined, scoring method.

Mass Score

Mass score is possibly the most definitive method for quantifying calcium within a lesion. The method is based on calculating the mean CT number of a calcification and multiplying the result by the volume of the calcification and a calibration factor to obtain the calcification mass. This is expressed this way:

$m_l = c\ CT_l\ v_l$

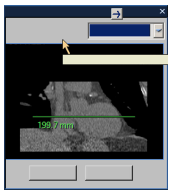
- The calcification mass is represented by m_l.
- The calcification volume, v_l, is obtained by multiplying the lesion area (in mm^2) that is above the defined threshold by the distance between the reconstructed slices (in mm).
- The calibration factor, c, is included in the software.

Calculate Lateral Thickness for Mass Score

When you use the Mass Score method for the first time, the Edit Lateral Thickness dialog automatically opens for you to specify the lateral thickness value. Access the drop-down menu and select the desired thickness.

- Small: < 32.0 cm lateral thickness;
- Medium: 32.0 - 38.0 cm lateral thickness;
- Large: > 38.0 cm lateral thickness; and
- From Surview. See section “Calculate Lateral Thickness from Surview” on page 300.

Calculate Lateral Thickness from Surview



You can also calculate the lateral thickness using the surview image. When you click **From Surview...** in the Edit Lateral Thickness dialog box, the surview image appears. If a surview was not loaded with the study, the application creates a coronal MPR in MIP mode in the middle of the volume.

1. A green line is displayed on the image.
2. Adjust the line as described in the tool tip: “Lateral thickness should be measured from skin-to-skin, at the level of the proximal ascending aorta, from an A/P surview image.”
3. Point the mouse on the line. The line turns yellow.
4. Move the line with the mouse as desired.
5. Adjust the ends of the line as desired with control points.

Area/step Method (Agatston)

The Area/Step method - the most commonly used scoring method - is based on Agatston score, which takes into account the Area of the calcified lesion and the average CT value within the lesion. This is the original Agatston method).

Step/Weight Factor	Value When CT Number Is Equal to or Greater Than	Value When CT Number Is Less Than Value
1	Threshold	200 HU
2	200	300 HU
3	300	400 HU
4	400	–
Score for the ROI = (step/weight factor) x (the Area of the lesion)		
The calculated score is normalized to slice thickness of 3 mm.		

The following scan parameters are required for Agatston Score protocol:

- Axial CT data
- Gated scan
- Non Contrast scan
- Thickness: 2.5 - 3 mm
- 120 kV
- mAs according to patient body habitus

For detailed information, please see Agatston Score Publication and 2016 SCCT/STR Guidelines:

[1] Arthur S. Agatston, Warren R. Janowitz, Frank J. Hildner, Noel R. Zusmer, Manuel Viamonte Jr. and Robert Detrano, "Quantification of coronary artery calcium using ultrafast computed tomography", JACC Vol. 15 No. 4 March 15. 1990:827-32. [2] Harvey S. Hecht a, Paul Cronin b, Michael J. Blaha c, Matthew J. Budoff d, Ella A. Kazerooni b, Jagat Narula e, David Yankelevitz f,

/881 * 2021-06-30

Philips

Suhny Abbara, "2016 SCCT/STR guidelines for coronary artery calcium scoring of noncontrast noncardiac chest CT scans: A report of the Society of Cardiovascular Computed Tomography and Society of Thoracic Radiology", Journal of Cardiovascular Computed Tomography xxx (2016) 1-11.

Continuous Weight-factor Method (Lesion Volume)

In this scoring method, which is based on spiral CT data acquisition, the volume and the weighting factor are continuous.

The lesion volume is obtained by multiplying the area (in mm^2) that is above the threshold, by the distance between reconstructed slices (in mm). This provides a score on a volumetric basis (in mm^3). The continuous weight factor (WC), for calcified lesions above the threshold, is calculated by the formula:

W_c= (CT-50) / 100

The Volumetric score is calculated as follows:

Score = (W_c) x (the lesion volume)

NOTICE

Add the Score of all ROIs attained for all images. The sum is the Total Score of the study.

NOTICE

Volume and Area are calculated differently per protocol, as they are based on the threshold defined for the protocol. If the thresholds differ, the volume/area calculation may vary.

Accuracy and Reproducibility

Using the recommended protocols for the total score measurements and calculations:

- Error: 25% typical
- Reproducibility: 25% typical

CAUTION

The estimated accuracy of Calcium Mass scores of 10 mg or higher is 20%. Lower scores may exhibit larger variability.

881 * 2021-06-30

Scan Protocols

On the scanner, one of the Cardiac Calcium Scoring-specific scan protocols should be selected for getting the best results from the Cardiac Calcium Scoring application.

NOTICE

Before continuing, refer to the “Instructions for Use” that came with your scanner.

CAUTION

For follow-up studies, always use the same scan protocol and scoring protocol as in the baseline measurements.

Cardiac Calcium Scoring Window

The Cardiac calcium scoring window shows the selected images.

Areas of pixel values above the threshold are marked in pink (in Agatston Score) when the Highlight feature is on (default state). Turn off the Highlight to display the original colors of the image, without highlighting.

To increase the accuracy of the procedure, enlarge the selected scoring images by choosing a screen format of one or four. You can also use the zoom function to display only the area of interest in the screen frames.

Cardiac Calcium Scoring Viewing Tools

Use the tools to change the Cardiac Calcium Scoring views.

See **Report**, **Film**, **CT Common Processes** and **CT Common Tools** for information on using common options, tools, functions, and processes.

Layout

The Layout function controls how the images display in the viewport. Click the Layout down-arrow to select from four image layout arrangements, 1x1, 2x2, 3x3, 4x4, and Custom, which allows you to set the number of images.

Selection

Selecting images allows you to perform the same manipulation on the selected image(s) of your choice, such as scrolling, panning, zooming, filming, or saving. The Selection buttons, from left to right, are:

- One image (at a time).

- A series of images.
- The screen (the whole window).
- All images loaded in the viewer.

When switching between selection modes, the active image in the new mode is the same image that was active beforehand.

Display

When switching between selection modes, the active image in the new mode is the same image that was active beforehand.

Protocols

Protocols allows you to select the scoring method used for the study. The default method is based on the original method used for the scan.

The Edit Protocol drop-down provides options for adding, editing and deleting protocols.

NOTICE

Before continuing, refer to the “Instructions for Use” that came with your scanner.

Highlight

Cardiac Calcium Scoring uses Highlight to mark in color the image regions that have pixel values within a user defined range.

Changing the highlight window affects only the display on the screen. It does not affect the threshold values used for score calculation.

Cardiac Calcium Scoring Functions

To access additional HeartBeat-CS functions, click the down arrow in the tab window, or hover the mouse over the tab window. The list of available functions displays.

Series

The Series tree displays a list of the studies and series that are loaded into the viewer, and also other elements (like batches) that have been created. Show Pictorials changes list to thumbnails.

Bookmarks

While using a viewer or an application, you can use a bookmark at any time to “save the current status” of your work.

Batch

The Batch function allows you to create a series of sequential images for viewing, saving, reporting and filming purposes.

Key Images

Save groups of images that can be reviewed in any system supporting the defined standard. See **Instructions for Use** > **Directory** > **Key Image Notes** for more information.

Vessel List (Seed Tab)

Seed allows you to control seed placement in the vessels. You have the option to add, edit or delete items in the vessel list:

- To Add vessel to the list, type a name in the top field of the Seed tab.

You can change the names of the vessels you create at any time. Right click on a user-created vessel name to display these options:

- Rename allows you to rename an existing vessel.
- Delete allows you to delete vessel from the list.
- Reset allows you to delete all created vessels from the list.

These options are not available for factory default settings.

Scoring Procedure

The scoring procedure consists of user and software steps.

User Steps

Opening the Cardiac Calcium Scoring application and selecting images for processing.

Selecting a scoring protocol from the menu.

Identifying a calcified region and relating it to a specific organ (artery or valve) by selection from a menu.

Marking the areas to be processed (ROI) on each image.

Software Step

Calculating the score (once the user steps are complete, results are calculated from the seeded areas).

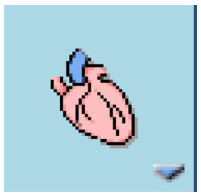
Open Cardiac Calcium Scoring Application

Images selected for scoring must be from the same series, with equal spacing between them, and whose slice thickness is equal to or greater than the spacing.

NOTICE

Before continuing, refer to the “Instructions for Use” that came with your scanner.

1. From the Directory, select the storage device from which to read image files.
2. Select a patient’s name from the patient list.
3. Select the appropriate series from the series list:
   - Must be a gated axial or helical scan.
   - Must be a single volume.
4. From the Analysis options, select (Cardiac) Calcium Scoring (Heartbeat CS).



The system launches the application with the selected images.

NOTICE

Since the scoring process provides quantitative results, all images from the region being scored must be selected, not just those images with visible calcifications.

Mark ROIs for Processing

You can mark areas for processing using a manual or automatic method. Once an area is defined, the ROI displays with the vessel color and name.

Use the Seed tools to define the ROI.

CAUTION

Do not use the ROI tools in the Common tool box.

The Manual seed tools provide a variety of shapes to manually draw the ROI (Circle, Polygon, Ellipse, Free ROI).

The One-click seed tool allows you to create the ROI using a single click.

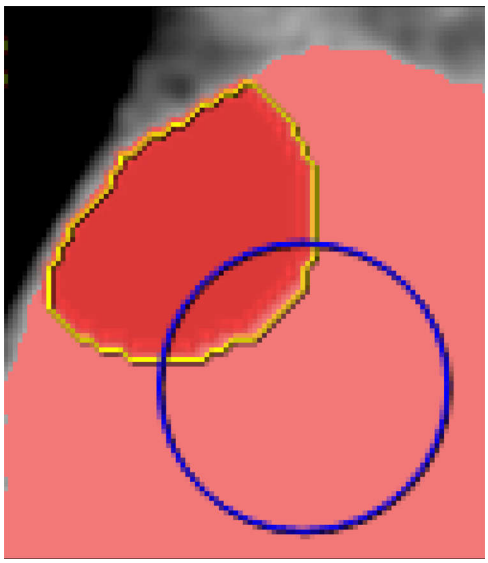
Use this procedure to mark the areas of calcification. Scoring is performed only on the marked areas.

1. Select an organ to mark from the list of vessels. The organ in the list becomes highlighted. Note that each vessel name has a different color.
2. Click the desired tool for marking the area:
   - **Manually Draw ROI**

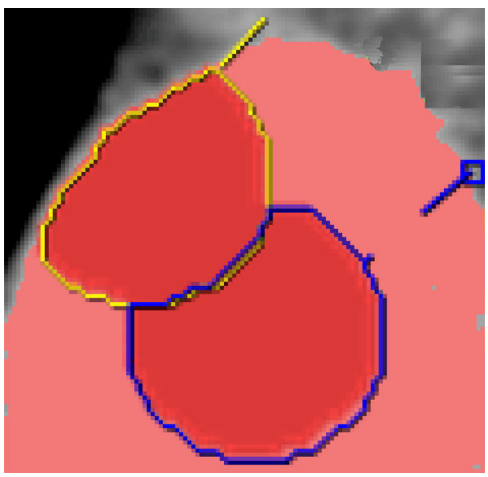
     Click and drag around the area you want to identify with the ROI. After you finish drawing an ROI, the ROI shrinks to include only the area that is calcified.

     If your manual ROI did not capture the entire calcified area, draw another ROI to capture more area. As shown below, you can overlap the first ROI with the second ROI, which then shrinks so there is no duplication of area. (Note that if your new ROI completely overlaps the old ROI, the new ROI is invalid.)

     Start Overlap

     Finish Overlap

   - **Use Automatic ROI**

If calcification extends across more than one vessel (e.g., it starts in the Left Main and continues into the LAD), **do not use the automatic ROI tool**. Perform slice-by-slice manual seeding until the entire lesion is identified. Otherwise, the lesion may be included in multiple vessel scores.

With the automatic tool, click on a pink highlighted calcified area within the selected area. The system automatically identifies the calcified volume (the automatic tool detects calcium on several slices if the calcification is contiguous), changes the color of the area, and adds it to the score calculation.

Click the Show table or Show graph icon to display score.

WARNING

To ensure the accuracy of the score, verify the placement of the ROI and correct manually if necessary.

NOTICE

Do not use the ROI tools in the Graphic tools. ROIs created with these tools are not included in the scoring calculations.

3. You can define ROIs in each image you want to analyze. For each vessel, an unlimited number of ROIs per image are allowed. Use the center wheel on the mouse to scroll to another image within the selected viewport.
4. To mark additional vessels, select another vessel from the Artery list and repeat.

NOTICE

A non-valid ROI (overlapped with nearby ROI or covering too small a calcification area, as defined in the scoring protocol) will not be taken into account in the calculation. It will display in gray. Only a valid ROI appears in the organ color.

NOTICE

Manually verify the accuracy of all automatic and semiautomatic functions to avoid misdiagnosis.

881 * 2021-06-30

Philips

Delete ROI

To delete an ROI created with the auto seed function, two options are available.

Delete segmented ROI(s). Click this button, then click on the ROI you want to delete. The ROI is deleted from all the slices which belong to this calcified volume that was marked with auto seed.

Delete Current ROI. Click this button, then click on the ROI you want to delete. (If more than one ROI belonging to same auto-seeded ROI exists on the current slice, only the ROI which was right clicked is deleted.)

NOTICE

You can also delete an ROI by right clicking on it, then selecting Delete.

Re-assign Vessel to ROI

To re-assign segmented calcium lesion ROI's, use the context menu (right-click). Select **Reassign to...** and select the labeled organ name in the sub-menu to reassign.

- Re-assignment for automatic ROIs is realized by deleting the ROI to be re-assigned and recreating the ROI for the new selected organ using the same seeding point. Thus, any conflicts due to intersections (in any slices of the ROI) with other ROIs are mitigated using the rules of the ROI creation process.
- Re-assignment for manual ROIs is possible only if the ROI to be reassigned does not intersect with other ROIs.
- Reassignment of the manual ROI is done by recreating the ROI for the new organ with the same characteristics of the old ROI (i.e. contour, statistics).

Display Selected ROI Values

After marking the ROI in one image, you can set the system to calculate the area, the volume, the average, the maximal CT number, and other parameters of the calcified lesion.

1. Click the **Plaque info** icon.
2. Click the parameters you want displayed.
3. Click **Ok**. The values you selected display near the marked ROI.

Save ROIs

You have the option of saving the ROIs in a separate entry in the Series List. When you reload the original images, the saved ROIs display on the images.

1. Click **Save ROIs as...** (from Common Tools, the Save as... function). The Saving results... dialog opens.
2. Accept the suggested Description, or enter a new name.

3. Select the Device, as desired.
4. Click **OK**.

Scoring Protocols

Selecting an appropriate protocol is important for viewing images in the Cardiac Calcium Scoring application.

NOTICE

Before continuing, refer to the “Instructions for Use” that came with your scanner.

Parameters Definition

Various preset scoring protocols are available. The preset protocols include these options:

- The original Agatston score, based on threshold value of 130 HU.
- Mass score protocol (calculates the score by taking into account each individual lesion volume, the CT value of each pixel in the lesion volume, and a calibration factor to obtain the calcification mass in mgHA, based on a threshold of 100 mgHA).

881 * 2021-06-30

CAUTION

The estimated accuracy of Calcium Mass scores of 10 mg or higher is 20%. Lower scores may exhibit larger variability.

The scoring protocol displays in the Scoring tools panel. The default protocol is the Agatston score. Use this procedure to select a different protocol:

- Click the box showing the default protocol.
- Select a scoring protocol from the list of preset protocols.

Philips

Protocol Options

You have the option to add, edit, or delete any protocol in the list. Use this procedure to access the protocol options.

1. Click the protocol icon to display the protocol options menu.
2. Select an option:
   - **Add.** New protocol box displays.
   - **Edit.** Edit protocol box displays.
   - **Delete.** Protocol is automatically removed from the list.

   The Edit protocol box includes the protocol name in the Name field.
3. Fill in the fields.
4. Click the desired option:
   - **Ok** to store the protocol and close the dialog box.
   - **Cancel** to close the dialog box without saving.

Display Scores

You can view the calcium score in either table or graph form.

Show Table

Click Show Table to toggle on or off the scoring results table. The system calculates the scoring along with the changes in the ROIs set for all the marked organs.

NOTICE

The active table may be added to the clipboard using **Ctrl + C** or by right-clicking on the table and selecting copy. The measurements may then be pasted into common document types, including plain text, Microsoft Word, and Microsoft Excel documents.

Right-click Options

Right click on the table (or click the small arrow in the upper right part of the table) to access these options:

- Score;
- #ROIs; and
- Area Sq. (sq. mm).

NOTICE

These options are only relevant when more than one series is being seeded in compare mode.

Use the Save As option to export the table information as text.

Use the Film option to export the table information to film.

Use the Report options to export the table information to the report.

Show Graph

When you have two or more series loaded, you can also view the results in graphical form. Click **Show Graph** to toggle on or off the scoring results graph. The system calculates the scoring along with the changes in the ROIs set for all the marked organs.

You cannot view the graph and the table simultaneously.

These cases are not included in the score or counted in the score table:

- an ROI covering calcifications with area smaller than the minimal area specified in the scoring protocol;
- an ROI overlapping another ROI; and
- an ROI not created by the Seed tools.

CAUTION

The estimated accuracy of Calcium Mass scores of 10 mg or higher is 20%. Lower scores may exhibit larger variability.

Relate Score to Database

NOTICE

Before continuing, refer to the “Instructions for Use” that came with your scanner.

Within this procedure, there is an option to relate the individual patient score to an asymptomatic population score database. The **MESA** database is supported, as described below.

MESA database - **M**ulti-**E**thnic **S**tudy of **A**therosclerosis for Risk stratification. The MESA Database calculator is based on the following references:

- Reference: Robyn L. McClelland, Hyoju Chung, Robert Detrano, Wendy Post and Richard A. Kronmal "Distribution of Coronary Artery Calcium by Race, Gender, and Age: Results from the Multi-Ethnic Study of Atherosclerosis (MESA)", Circulation 2006

This article provides information that can be used to examine whether a patient has a high CAC score relative to others with the same age, gender, and race/ethnicity who do not have clinical cardiovascular disease or treated diabetes. These results come from MESA, a prospective cohort study of the prevalence, risk factors, and progression of subclinical cardiovascular disease, which was done on a United States population.

When the Calcium score result, according to Agatston Protocol is obtained, a percentile value is presented at the bottom of the scoring table or in the last column of the table if several series are displayed.

The indication for the **MESA** database is only visible if the Agatston score protocol is selected.

Score Database

See the "Instructions for Use" that came with your scanner for the parameters of “Calcium Scoring” or “Body” scan protocols included in the database.

CAUTION

If using the Calcium Scoring application on scanners prior to Brilliance 4, you must use the 0.5 Rotation time.

Scan Parameters

Philips Scan Parameters for Heartbeat Calcium Scoring Protocol

Axial/Helix	Tagging	KV	mAs	COLLIMATION	RESOLUTION	FILTER[1]
Axial	ECG	120	55-165	6x3	STANDARD	B
Axial	ECG	120	55-165	6x3	UFDETAIL[2]	B
Axial	ECG	120	55-165	6x3	ULTRAFAST	B
Axial	ECG	120	55-165	8x3	STANDARD	B
Axial	ECG	120	55-165	8x3	UFDETAIL[2]	B
Axial	ECG	120	55-165	8x3	ULTRAFAST	B
Axial	ECG	120	55-165	16x2.5	STANDARD	B
Axial	ECG	120	55-165	16x2.5	STANDARD	CB
Axial	ECG	120	55-165	16x2.5	DETAILED	B
Axial	ECG	120	55-165	16x2.5	DETAILED	CB
Axial	ECG	120	55-165	32x0.625	STANDARD	B

/881 * 2021-06-30

Philips

Axial/Helix	Tagging	KV	mAs	COLLIMATION	RESOLUTION	FILTER[1]
Axial	ECG	120	55-165	32x0.625	DETAILED	B
Axial	ECG	120	55-165	32x0.625	STANDARD	CB
Axial	ECG	120	55-165	32x0.625	DETAILED	CB
Axial	ECG	120	55-165	40x0.625	STANDARD	B
Axial	ECG	120	55-165	40x0.625	STANDARD	CB
Axial	ECG	120	55-165	40x0.625	DETAILED	B
Axial	ECG	120	55-165	40x0.625	DETAILED	CB
Axial	ECG	120	55-165	64x0.625	STANDARD	B
Axial	ECG	120	55-165	64x0.625	DETAILED	B
Axial	ECG	120	55-165	64x0.625	STANDARD	CB
Axial	ECG	120	55-165	64x0.625	DETAILED	CB
Axial	ECG	120	55-165	128x0.625	STANDARD	B
Axial	ECG	120	55-165	128x0.625	DETAILED	B
Axial	ECG	120	55-165	128x0.625	STANDARD	CB
Axial	ECG	120	55-165	128x0.625	DETAILED	CB
Axial	ECG	120	55-165	112x0.625	STANDARD	B
Axial	ECG	120	55-165	112x0.625	DETAILED	B
Axial	ECG	120	55-165	112x0.625	STANDARD	CB
Axial	ECG	120	55-165	112x0.625	DETAILED	CB
Axial	ECG	120	55-165	96x0.625	STANDARD	B
Axial	ECG	120	55-165	96x0.625	DETAILED	B
Axial	ECG	120	55-165	96x0.625	STANDARD	CB
Axial	ECG	120	55-165	96x0.625	DETAILED	CB

- [1]B filter: Standard resolution, recommended for CTA, routine abdomen, pelvis and spine. High resolution: Offers moderate sharpness and noise. Ultra-High Resolution: Moderate noise for soft tissue.
- [1]CB filter: Smooth, cardiac scan only
- [2] UFDETAIL = Ultra-Fast Detailed

For more details, please refer to the Instructions for Use that came with your scanner.

881 * 2021-06-30

Philips

Missing Parameters

When loading series with missing parameters, such as age, gender, ethnicity (if relevant), an indication is displayed that asks from the user to enter the missing, relevant parameters via the **Patient Information** dialog.

If some of the parameters are not compatible to the database parameters, then another indication is displayed that notifies the user about it.

The percentile is calculated only if the parameters match the database parameters.

The **Use nearest supported age for MESA percentile** option in the Patient Information window is enabled if the Patient Age is outside the supported range (45-84 years).

The **Use nearest supported age for MESA percentile** and **Show results for all 4 ethnicities** are automatically selected if the relevant option under Calcium Scoring in **Preferences (Viewing Applications)** are selected.

NOTICE

Before continuing, refer to the “Instructions for Use” that came with your scanner.

If all the parameters are missing from DICOM, a dialog box pops up. Only missing parameters are displayed in the popup.

Only missing DICOM parameters can be edited by the user.

- Gating menu options are: ECG and Other.
- Phase options are: 75%, 85%, and Other.

NOTICE

You may see a database even if entered parameters do not match the scan.

If some of the parameters are not compatible with the database parameters, an additional message notifies the user.

Cardiac Calcium Scoring References

The following articles contain information relevant to the use of the Scoring algorithms to quantify calcium in the coronary arteries.

Agatston A., Janowitz W., Hindler F., et al., Quantification of Coronary Artery Calcification using UltraFast Computed Tomography: J Am College Cardiol 1990; 15; 827-832.

Broderick L.S., Shemesh J., Wilensky R.L., et al., Measurement of Coronary Artery Calcium with Dual-Slice Helical CT Compared with Coronary Angiography: Evaluation of CT Scoring Methods, Interobserver Variations, and Reproducibility: AJR 1996; 167; 439-444.

/881 * 2021-06-30

Philips

McClelland, R.L.. Chung, H., Detrano, R., Post, W. and Kronmal, R.A., "Distribution of Coronary Artery Calcium by Race, Gender, and Age: Results from the Multi-Ethnic Study of Atherosclerosis (MESA)", Circulation 2006.

Schmermund A, Silber S, et al., "Age and Gender Distribution of Coronary Artery Calcium Measured by Four-Slice Computed Tomography in 2,030 Persons With no Symptoms of Coronary Artery Disease", AJC 2002;90:168-173.

Shemesh J., Apter S., Rosenman J., et al., Calcification of Coronary Arteries: Detection and Quantification with Double Helix CT: Radiology 1995; 197; 779-783.

Wexler L., Brundage B., Crouse J., et al., Coronary Artery Calcification: Pathophysiology, Epidemiology, Imaging Methods, and Clinical Implications: A Statement for Health Professionals from the American Heart Association. Circulation 1996; 94; 1175-1192.

MESA Database Calculator

The MESA Database calculator is based on the following references – [Robyn L. McClelland, Hyoju Chung, Robert Detrano, Wendy Post and Richard A. Kronmal "Distribution of Coronary Artery Calcium by Race, Gender, and Age: Results from the Multi-Ethnic Study of Atherosclerosis (MESA)", Circulation 2006]

Image Quality Assurance

Quality assurance procedures for the Cardiac Calcium Scoring application must be followed. See the Image Quality Assurance section in the Philips CT user manual regarding QA procedures for the scanner.

CAUTION

Because the cardiac calcium scoring function supplies quantitative results, following the QA procedure is mandatory.

881 * 2021-06-30

Philips