



SOMATOM Sensation 10 Application Guide

Special Protocols
Software Version A70

SIEMENS
medical

The information presented in this application guide is for illustration only and is not intended to be relied upon by the reader for instruction as to the practice of medicine. Any health care practitioner reading this information is reminded that they must use their own learning, training and expertise in dealing with their individual patients.

This material does not substitute for that duty and is not intended by Siemens Medical Solutions Inc., to be used for any purpose in that regard. The drugs and doses mentioned herein were specified to the best of our knowledge. We assume no responsibility whatsoever for the accuracy of this information.

Variations may prove necessary for individual patients. The treating physician bears the sole responsibility for all of the parameters selected.

The pertaining operating instructions must always be strictly followed when operating the SOMATOM Sensation 10. The statutory source for the technical data are the corresponding data sheets.

We express our sincere gratitude to the many customers who contributed valuable input.

Special thanks to the former authors and editors of this application guide, Bettina Klingemann and Dr. Xiaoyan Chen for their great efforts and contribution.

To improve future versions of this application guide, we would highly appreciate your questions, suggestions and comments.

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

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Content

HeartView CT

HeartView CT is a clinical application package specifically tailored to cardiovascular CT studies.

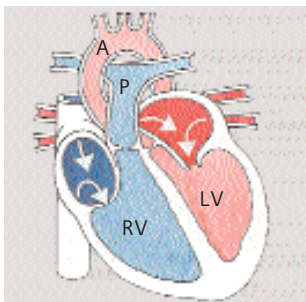
The Basics

Important Anatomical Structures of the Heart

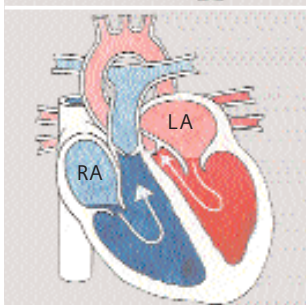
Four chambers:

- Right atrium – receives the deoxygenated blood from the body circulation through the superior and inferior vena cava, and pumps it into the right ventricle
- Right ventricle – receives the deoxygenated blood from the right atrium, and pumps it into the pulmonary circulation through the pulmonary arteries
- Left atrium – receives the oxygenated blood from the pulmonary circulation through the pulmonary veins, and pumps it into the left ventricle
- Left ventricle – receives the oxygenated blood from the left atrium, and pumps it into the body circulation through the aorta

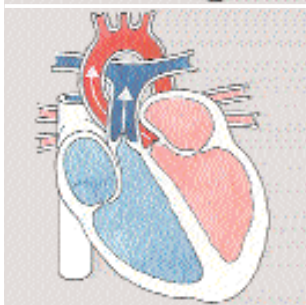
HeartView CT



*Fig. 1:
Blood fills both atria*



*Fig. 2:
Atria contract, blood
enters ventricles*



*Fig. 3:
Ventricles contract,
blood enters into
aorta and pulmonary
arteries*

- A: Aorta
- P: Pulmonary Artery
- RV: Right Ventricle
- LV: Left Ventricle
- RA: Right Atrium
- LA: Left Atrium

HeartView CT

Coronary arteries:

- Right coronary artery (RCA)

Right coronary artery supplies blood to the right atrium, right ventricle, and a small part of the ventricular septum.

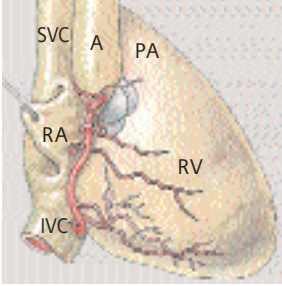


Fig. 4: Front view



Fig. 5: Conventional Angiography

SVC: Superior Vena Cava

IVC: Inferior Vena Cava

RA: Right Atrium

RV: Right Ventricle

A: Aorta

PA: Pulmonary Artery

- Left coronary artery (LCA)

Left coronary artery supplies blood to the left atrium, left ventricle and a large part of the ventricular septum.

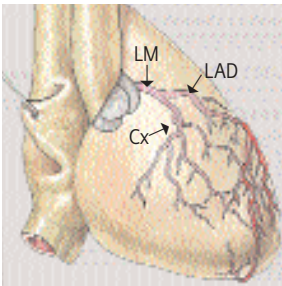


Fig. 6: Front view



Fig. 7: Conventional Angiography

LM: Left Main Artery

LAD: Left Anterior Descending Artery

Cx: Circumflex Artery

Cardiac Cycle and ECG

The heart contracts when pumping blood and rests when receiving blood. This activity and lack of activity from a cardiac cycle, can be illustrated by an Electrocardiograph (ECG) (Fig. 8).

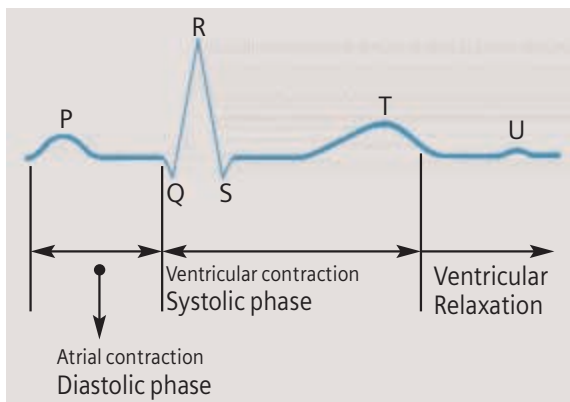


Fig. 8

To minimize motion artifacts in cardiac images, two requirements are mandatory for a CT system:

- Fast gantry rotation to minimize the time it takes to acquire the necessary scan data to reconstruct an image.
- Prospective triggering of image acquisition in a sequential mode or retrospective gating of image reconstruction in a spiral mode based on the ECG recording in order to obtain images during the diastolic phase with least cardiac motion.

Temporal Resolution

Temporal resolution, also called time resolution, represents the time window of the data that is used for image reconstruction. It is essential for cardiac CT imaging – the higher the temporal resolution, the fewer the motion artifacts. With the SOMATOM Sensation 10, temporal resolution can be achieved down to 125 ms.

Technical Principles

Basically, there are two different technical approaches for cardiac CT acquisition:

- Prospective ECG triggered sequential scanning.
- Retrospectively ECG gated spiral scanning.

In both cases, an ECG is recorded and used to either initiate prospective image acquisition (ECG triggering), or to perform retrospective image reconstruction (ECG gating). Only scan data acquired in a user-selectable phase of cardiac cycle is used for image reconstruction. The temporal relation of the image data interval relative to the R-waves is predefined, which can be either relative (given as a certain percentage of the RR-interval time) or absolute (given in ms) and either forward or reverse.

Relative – delay: a given percentage of R-R interval (%RR) relative to the onset of the previous or the next R-wave (Fig. 9, 10).

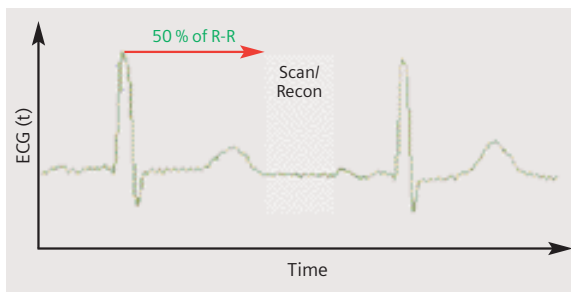


Fig. 9

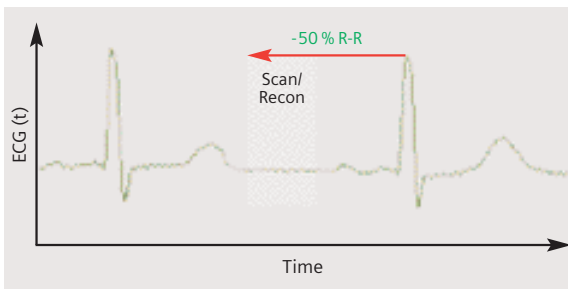


Fig. 10

Absolute – delay: a fixed time delay after the onset of the R-wave (Fig. 11).

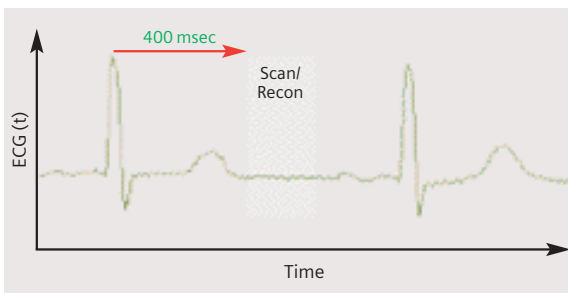


Fig. 11

Absolute – reverse: a fixed time delay prior to the onset of the next R-wave (Fig. 12).

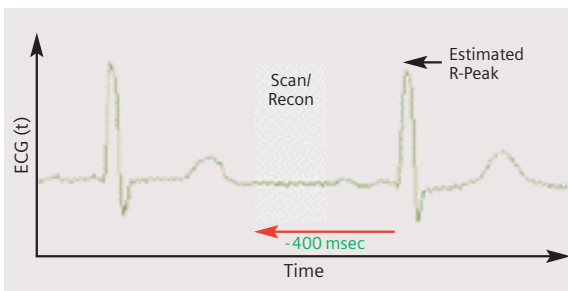


Fig. 12

Prospective ECG-Triggering Versus Retrospective ECG-Gating

With prospective ECG-triggering, the heart volume is covered in a “step-and-shoot” technique. The patient’s ECG-signal is used to start sequential scans with a pre-defined offset to the R-waves of the patient’s ECG. With retrospective ECG-gating, the heart volume is covered continuously by a spiral scan. The patient’s ECG-signal is recorded simultaneously to allow a retrospective selection of the data segments used for image reconstruction. Prospective ECG-triggering has the benefit of smaller patient dose than ECG-gated spiral scanning, since scan data is acquired in the previously selected heart phases only. It does, however, not provide continuous volume coverage with overlapping slices and mis-registration of anatomical details may occur. Furthermore, reconstruction of images in different phases of the cardiac cycle for functional evaluation is not possible. Since ECG-triggered sequential scanning depends on a reliable prediction of the patient’s next RR-interval by using the mean of the preceding RR-intervals, the method should not be used for patients with arrhythmia and irregular heart rates. To maintain the benefits of ECG-gated spiral CT but reduce patient dose ECG-controlled dose-modulation is available.

Placement of ECG-Electrodes

The correct placement of the ECG electrodes is essential in order to receive a clear ECG signal with marked R-Waves. Incorrect placement of the electrodes will result in an unstable ECG signal which is sensitive to movements of the patient during the scan.

US Version (AHA standard)

White Electrode

on the right mid-clavicular line, directly below the clavicle

Black Electrode:

on the left mid-clavicular line, 6 or 7 intercostal space

Red Electrode:

right mid-clavicular line, 6 or 7 intercostal space



Europe Version (IEC standard)

Red Electrode

on the right mid-clavicular line, directly below the clavicle

Yellow Electrode:

on the left mid-clavicular line, 6 or 7 intercostal space

Black Electrode:

right mid-clavicular line, 6 or 7 intercostal space



Preview Series Reconstruction

The Preview Series should be used to define the optimal time window for image reconstruction in ECG-gated spiral scanning, before the full series is reconstructed. A default value of 60% relative gating (or -400 ms absolute reverse gating) can be used as an initial setup for the optimization process which is best performed as follows:

- select an image level displaying the mid RCA.
- choose 60% (or -400 ms) reconstruction phase setting.
- reconstruct a preview series at this level of the RCA by clicking on the “Preview Series” button in the Trigger card: a series of images with different phase setting at the selected anatomical level of the RCA will be reconstructed.
- choose the image with least motion artifacts.
- reconstruct the whole dataset with the phase setting you selected. Please note that you have to enter this phase setting manually in the trigger card.

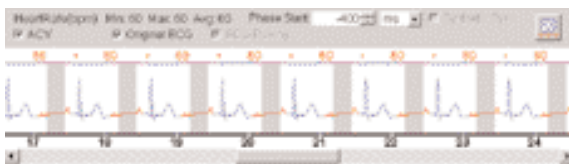
An example for a preview series at the correct anatomical level with optimal and sub-optimal selection of the phase setting is shown below. Usually this procedure results in good image quality for the right and the left coronary artery, especially at higher and inconsistent heart rates individual optimization for left and right coronary artery may be necessary. In most cases, the RCA requires an earlier phase in the cardiac cycle to obtain the period of least motion, e. g. RCA at 40%, LAD at 60%.



Example of a preview series at the correct anatomical level (mid RCA), demonstrating the importance of optimized phase setting. Patient with an average heart rate of 63 bpm.

Left: 57%, mid: 61%, right: 65% relative delay.

The image at 61% relative delay shows the least motion artifacts. In this example, even a slight change of the phase setting from 61% to 65% deteriorates image quality.



ECG-Trace Editor

The ECG trace editor is used to modify the ECG signal. This editing tool is available after spiral scan data have been acquired. By using the right mouse menu on the Trigger card you have access to several modification tools for the ECG Sync, such as Delete, Disable, Insert. In patients with only single or few extra-systolic beats overall image quality may be improved by editing the ECG prior to reconstruction. Deleting the corresponding R-peaks prevents image reconstruction in the extra-systolic heart periods. Please keep in mind that absolute gating (in ms) must be chosen if R-peaks are deleted. Although ECG-gated spiral scanning is less sensitive to variable heart rates than ECG-triggered sequential scanning, the examination of patients with complex arrhythmia that results in unpredictable variations of the RR-intervals (e. g. complex ventricular arrhythmia or multiple extra beats) can result in limited image quality and should be performed in exceptional cases only.

ECG-Pulsing

ECG-pulsing is a dedicated technique used for online dose modulation in ECG-gated spiral scanning. During the spiral scan, the output of the X-ray tube is modulated according to the patient's ECG. It is kept at its nominal value during a user-defined phase of the cardiac cycle, in general the mid- to end-diastolic phase.

During the rest of the cardiac cycle, the tube output is reduced to 20% of its nominal value. The length of the plateau with full dose is 450 ms, which is sufficient to retrospectively shift the image reconstruction interval for patient-individual fine-tuning of the image reconstruction phase. The tube current is reduced and not switched off to allow for image reconstruction throughout the entire cardiac cycle. Even though their signal-to-noise ratio is decreased, the low-dose images are sufficient for functional evaluation. Clinical studies have demonstrated dose reduction by 30-50% depending on the patient's heart rate using ECG-pulsing. ECG-pulsing can be switched on/off by the user on the Trigger card (Fig. 14). When using ECG-pulsing, the desired reconstruction phase has to be estimated and entered into the Trigger card prior to scanning, since it determines the time interval of maximum dose. ECG-pulsing should not be used for patients with irregular heart rates and arrhythmia.

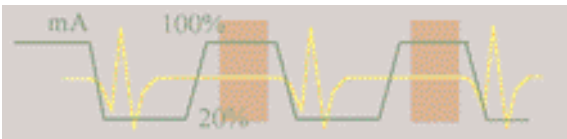


Fig. 14: Dose modulation with ECG pulsing.

ACV on/off

On the Trigger card, ACV (Adaptive Cardio Volume reconstruction) can be switched on/off by the user. With ACV off, single segment reconstruction is performed for all heart rates. Data acquired in one heart cycle are used for the reconstruction of each image, and the temporal resolution is independent of the heart rate. Temporal resolution is 250 ms for 0.5 s gantry rotation time. With ACV on, the system automatically switches between single segment and two segment reconstruction depending on the patient's heart rate. For heart rates below 65 bpm at 0.5 s rotation time, single segment reconstruction is performed. For heart rates exceeding 65 bpm, two segment reconstruction is performed, using scan data acquired in two subsequent heart cycles to improve temporal resolution. With ACV on, temporal resolution is constant for heart rates below 65 bpm (250 ms for 0.5 s gantry rotation time). For heart rates above 65 bpm, temporal resolution varies between 125 ms and 250 ms depending on the patient's heart rate, reaching its optimum (125 ms) at 69 bpm. Temporal resolution as a function of the patient's heart rate is shown in Fig. 15. We recommend to switch ACV on.

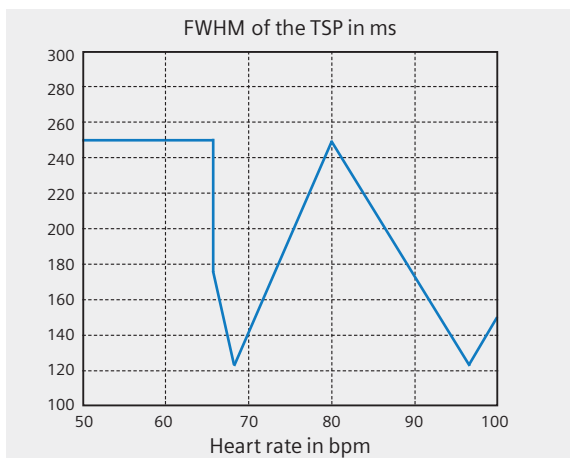
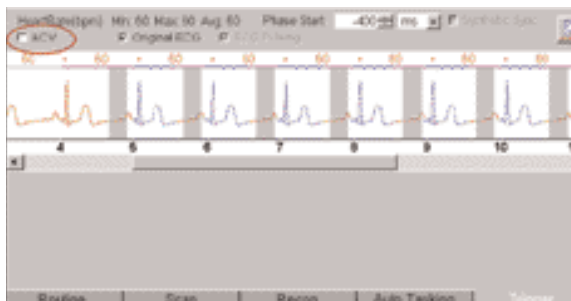


Fig. 15: Temporal resolution as a function of the patient's heart rate for 0.5 s gantry rotation time.



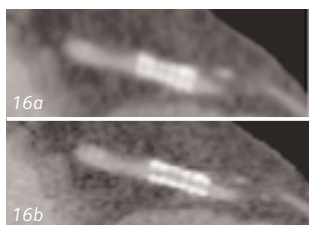
ASA-Filter

For the VA70 the special kernel B46f and the ASA-filter are now routinely available and can be selected in each ECG-gated spiral scan protocol.

We recommend to reconstruct 1 mm slices and use the kernel B30f for standard coronary CTA, including MPR, MIP and VRT.

The 0.75 mm reconstructed slice width should be reserved for detail viewing of stents or severely calcified coronary arteries. In these cases, the use of the kernel B46f in combination with the ASA-filter, may yield superior results.

Image examples are shown in figure 16.



*Fig. 16:
Image reconstruction
without (16a)
and with (16b)
Kernel B46f in
combination with
ASA-Filter.*

How to do it

Calcium Scoring

This application is used for identification and quantification of calcified lesions in the coronary arteries. It can be performed with both Prospective ECG triggering (sequential scanning) and Retrospective gating (spiral scanning) techniques. The following scan protocols are predefined:

- **CaScore**
 - Standard spiral scanning protocol with ECG gating and a 0.5 s rotation time
- **CaScoreSeq**
 - Sequential scanning protocol with ECG triggering

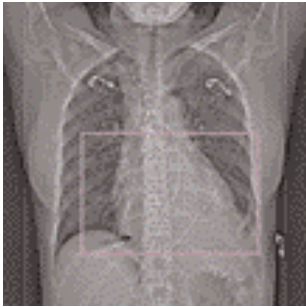
Hints in General

- Kernel B35f is dedicated to calcium scoring studies, providing most accurate determination of the HU-value of small calcified lesions. To ensure the best image quality and correlation to known reference data, other kernels are not recommended.
- Use the ECG-triggered protocol for low-dose scanning except for patients with arrhythmia. Use the ECG gated protocol when accuracy and/or reproducibility are essential, e. g. for follow-up studies of calcium scoring.
 - With 0.42 s gantry rotation time, temporal resolution varies between 105 ms and 210 ms depending on the patient's heart rate, reaching its optimum (105 ms) at 81 bpm, see Fig. 15.
 - We recommend a tube voltage of 120 kV. To reduce patient dose, tube voltage may be lowered to 100 kV or even 80 kV. With 80 kV, at least 250 eff. mAs should be used. 80 kV is not recommended for obese patients.
- The protocol with 0.5 s rotation time should be applied to all examinations.

CaScore

Indications:

This is a standard spiral scanning protocol, using an ECG gating technique for coronary calcium scoring studies, with a rotation time of 0.5 seconds.



*Topogram:
AP, 512 mm.
From the carina to
the apex of the heart.
A typical range of
15 cm covering the
entire heart can
be done in 19.2 s.*

	CaScore
kV	120
Effective mAs	133
Slice collimation	1.5 mm
Slice width	3.0 mm
Feed/Rotation	4.1 mm
Rotation time	0.5 sec.
Temporal resolution	up to 125 ms*
Kernel	B35f
Increment	1.5 mm
Image order	cr-ca
CTDI _{Vol}	10.0 mGy
Effective dose	Male: 2.2 mSv** Female: 3.3 mSv**

* Depends on heart rate.

** Reduced by 30%-50% with ECG-pulsing.

CaScoreSeq

Indications:

This is a sequential scanning protocol using an ECG triggering technique for coronary calcium scoring studies.



*Topogram:
AP, 512 mm.
From the carina to
the apex of the heart
and the scan length
is 15.3 cm.*

If you apply API for image acquisition, please make sure that the breath-hold interval in the Patient Model Dialog is longer than the total scan time, e. g. 50 s, otherwise the image acquisition will be interrupted by the default breath-hold interval. This does not apply when API is not activated.

	CaScSeq
<i>kV</i>	120
<i>Effective mAs</i>	30
<i>Slice collimation</i>	1.5 mm
<i>Slice width</i>	3.0 mm
<i>Feed/Scan</i>	12.0 mm
<i>Rotation time</i>	0.5 sec.
<i>Temporal resolution</i>	250 ms
<i>Kernel</i>	B35f
<i>Image order</i>	cr-ca
<i>CTDI_{Vol}</i>	2.3 mGy
<i>Effective dose</i>	Male: 0.5 mSv* Female: 0.7 mSv*

* Reduced by 30%-50% with ECG-pulsing.

Coronary CTA

This is an application for imaging of the coronary arteries with contrast medium.

We recommend to use only ECG gated spiral scanning. The following scan protocols are predefined:

- **CoronaryCTA**
 - Standard spiral scanning protocol with ECG gating, using a rotation time of 0.5 seconds.
- **CorCTA_LowHeartRate**
 - Special spiral scanning protocol with ECG gating, using a 0.5 second rotation time, for patients with a heart rate below 50 bpm.
- **CoronaryCTA100kV**
 - This protocol is identical to “CoronaryCTA”, except that it uses 100 kV tube voltage instead of 120 kV.

Hints in General

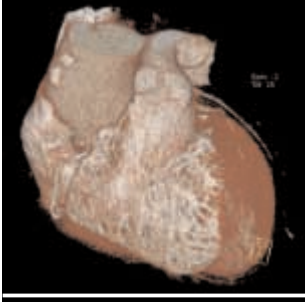
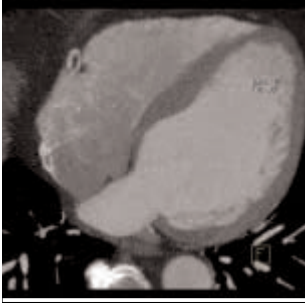
Contrast Medium:

For homogeneous contrast enhancement in the coronary arteries optimized contrast protocols are mandatory. The use of bolus tracking is helpful, with an automatic start of the spiral scan as soon as a contrast threshold of 100 HU has been reached in the ascending aorta. Please note that correct placement of the ROI in the ascending aorta is essential.

An example for an optimized contrast protocol is: Use 100 ml of contrast agent with a density of 320 mg/ml at a flow rate of 4 ml/s followed by 40 ml of saline chaser (double head injector).

For further information on the Bolus Tracking Application, please refer to the chapter “Bolus Tracking”.

- Kernel B35f is dedicated to calcium scoring studies, providing most accurate determination of the HU-value of small calcified lesions. To ensure the best image quality and correlation to known reference data, other kernels are not recommended.
- Use the ECG-triggered protocol for low-dose scanning except for patients with arrhythmia. Use the ECG gated protocol when accuracy and/or reproducibility are essential, e. g. for follow-up studies of calcium scoring.
 - With 0.42 s gantry rotation time, temporal resolution varies between 105 ms and 210 ms depending on the patient's heart rate, reaching its optimum (105 ms) at 81 bpm, see Fig. 15.
 - We recommend a tube voltage of 120 kV. To reduce patient dose, tube voltage may be lowered to 100 kV or even 80 kV. With 80 kV, at least 250 eff. mAs should be used. 80 kV is not recommended for obese patients.
- The protocol with 0.42 s Rotation Time can be applied to all examinations for HeartView CT. Temporal resolution for cardiac imaging can be achieved at down to 105 ms. The temporal resolution for the protocol with 0.5 s Rotation Time can be achieved at down to 125 ms.
- We recommend a tube voltage of 120 kV. If the tube voltage is lowered to 80 kV please use at least effective mAs 250. The use of 80 kV is not advised for large patients.



CoronaryCTA

Indications:

This is a standard spiral scanning protocol, using a rotation time of 0.5 s, with an ECG gating technique for coronary CTA studies.



*Topogram:
AP, 512 mm.
Approximately, from
the carina to the
apex of the heart.
A typical range of
12 cm covering the
entire heart can
be done in 30.2 s.*

	CorCTA
kV	120
Effective mAs	500
Slice collimation	0.75 mm
Slice width	1.0 mm
Feed/Rotation	2.0 mm
Rotation time	0.5 sec.
Temporal resolution	up to 125 ms*
Kernel	B30f
Increment	0.5 mm
Image order	cr-ca
CTDI _{Vol}	42.0 mGy
Effective dose	Male: 8.2 mSv** Female: 12.1 mSv**

* Depends on heart rate.

** Reduced by 30%-50% with ECG-pulsing.

CorCTA_LowHeartRate

Indications:

This is a special spiral scanning protocol for coronary CTA studies. It uses ECG gating technique and a 0.5 s rotation time, and should be used for patients with heart rate below 50 bpm.



*Topogram:
AP, 512 mm.
Approximately, from
the carina to the
apex of the heart.
A typical range of
12 cm covering the
entire heart can
be done in 38.8 s.*

	CorCTA_Low
<i>kV</i>	120
<i>Effective mAs</i>	650
<i>Slice collimation</i>	0.75 mm
<i>Slice width</i>	1.0 mm
<i>Feed/Rotation</i>	1.6 mm
<i>Rotation time</i>	0.5 sec.
<i>Temporal resolution</i>	up to 125 ms*
<i>Kernel</i>	B30f
<i>Increment</i>	0.5 mm
<i>Image order</i>	cr-ca
<i>CTDI_{Vol}</i>	54.6 mGy
<i>Effective dose</i>	Male: 10.8 mSv** Female: 16.2 mSv**

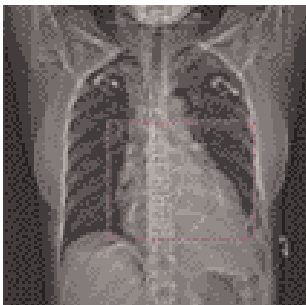
* Depends on heart rate.

** Reduced by 30%-50% with ECG-pulsing.

CoronaryCTA100kV

Indications:

This is a spiral scanning protocol, using a rotation time of 0.5 s, and 100kV tube voltage, with an ECG gating technique for coronary CTA studies. As consequence of the changed parameters (100 kV, 600 mAs) the patient dose will be reduced by 30%.



*Topogram:
AP, 512 mm.
Approximately, from
the carina to the
apex of the heart.
A typical range of
12 cm covering the
entire heart can
be done in 30.2 s.*

	CorCTA
kV	100
Effective mAs	500
Slice collimation	0.75 mm
Slice width	1.0 mm
Feed/Rotation	2.0 mm
Rotation time	0.5 sec.
Temporal resolution	up to 125 ms*
Kernel	B30f
Increment	0.5 mm
Image order	cr-ca
CTDI _{Vol}	25.0 mGy
Effective dose	Male: 5.0 mSv** Female: 7.3 mSv**

* Depends on heart rate.

** Reduced by 30%-50% with ECG-pulsing.

Aortic and Pulmonary Studies

The purpose of these applications is to reduce motion artifacts in the lung, the aorta and the pulmonary arteries due to transmitted cardiac pulsation. It is intended for imaging the aorta and pulmonary arteries with contrast medium and ECG-triggered sequential scanning or ECG-gated spiral scanning, e. g. for aortic dissection or pulmonary emboli. A special protocol is available for high-resolution interstitial lung studies with ECG-triggered sequential scanning. The following scan protocols are predefined:

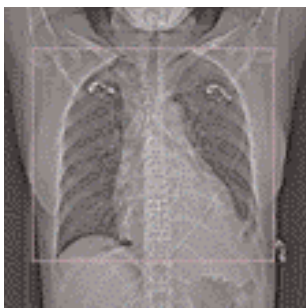
- **ThoraxECGHR**
 - Sequential scanning protocol with ECG triggering
- **AngioECG**
 - Spiral scanning protocol with ECG gating
- **AngioECGSeq**
 - Sequential scanning protocol with ECG triggering, using a rotation time of 0.5 seconds.

ThoraxECGHR

Indications:

This is a sequential scanning protocol with an ECG triggering technique for interstitial studies of the lungs, especially for the lesions in the pericardial region.

The scan length is 23.9 cm.



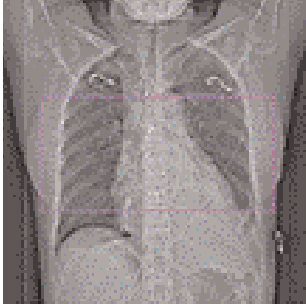
*Topogram:
AP, 512 mm.
From the apex of
the lung to the lung
base.*

	ThorECGHR
<i>kV</i>	120
<i>Effective mAs</i>	120
<i>Slice collimation</i>	0.75 mm
<i>Slice width</i>	0.75 mm
<i>Feed/Scan</i>	6.0 mm
<i>Rotation time</i>	0.75 sec.
<i>Temporal resolution</i>	375 ms
<i>Kernel</i>	B70s
<i>Image order</i>	cr-ca
<i>CTDI_{Vol}</i>	10.1 mGy
<i>Effective dose</i>	Male: 1.3 mSv Female: 1.6 mSv

AngioECG

Indications:

This is a spiral scanning protocol with an ECG gating technique for aortic and pulmonary studies.



*Topogram:
AP, 512 mm.
From the aorta arch
to the tip of the
sternum.
A typical range of
30 cm can be covered
in 27.6 s.*

	ThorECG
<i>kV</i>	120
<i>Effective mAs</i>	200
<i>Slice collimation</i>	1.5 mm
<i>Slice width</i>	3.0 mm
<i>Feed/Rotation</i>	5.6 mm
<i>Rotation time</i>	0.5 sec.
<i>Temporal resolution</i>	up to 125 ms*
<i>Kernel</i>	B30f
<i>Increment</i>	3.0 mm
<i>Image order</i>	cr-ca
<i>CTDI_{Vol}</i>	15.0 mGy
<i>Effective dose</i>	Male: 5.7 mSv Female: 7.3 mSv

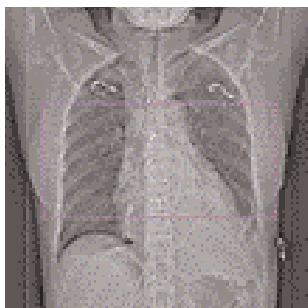
* Depends on heart rate.

AngioECGSeq

Indications:

This is a sequential scanning protocol with an ECG triggering technique for high-resolution interstitial lung studies.

The scan length is 11.9 cm.



*Topogram:
AP, 512 mm.
From the aortic arch
to the apex of the
heart.*

If you apply API for a single breathhold acquisition, please make sure that the breathhold interval in the Patient Model Dialog is longer than the total scan time, e. g. 50 s, otherwise the image acquisition will be interrupted by the default breathhold interval. This does not apply when API is not activated.

For longer ranges, e. g. the entire thoracic aorta, that can not be acquired within a single breathhold, please ensure that the breathhold interval in the Patient Model Dialog is set up correctly, according to the patient's level of cooperation.

HeartView CT

	ThorECG
<i>kV</i>	120
<i>Effective mAs</i>	120
<i>Slice collimation</i>	1.5 mm
<i>Slice width</i>	1.5 mm
<i>Feed/Scan</i>	12.0 mm
<i>Rotation time</i>	0.5 sec.
<i>Temporal resolution</i>	250 ms
<i>Kernel</i>	B30f
<i>Image order</i>	cr-ca
<i>CTDI_w</i>	8.8 mGy
<i>Effective dose</i>	Male: 1.5 mSv Female: 2.2 mSv

Additional Important Information

By default, the “Synthetic Trigger” (ECG triggered scanning) or “Synthetic Sync” (ECG gated scanning) is activated for all predefined cardiac scan protocols (Fig. 1 and 2). It is recommended to always keep activated for examinations with contrast medium.

In case of ECG signal loss during the acquisition, this will ensure the continuation of the triggered scans or allows an ECG to be simulated for retrospective gating. If it is deactivated, the scanning will be aborted in case of ECG signal loss during the acquisition.

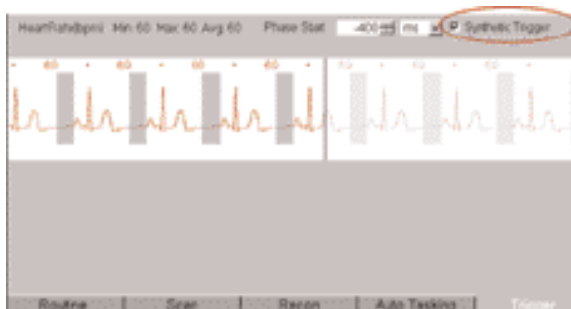


Fig. 1



Fig. 2



You can activate the “Auto load in 3D” function on the Examination card/Auto Tasking and link it to a recon job. If the postprocessing type is chosen from the pull down menu, the reconstructed images will be loaded automatically into the 3D card on the Navigator with the corresponding postprocessing type.

On the 3D card you have the possibility to create MPR, MIPthin Range Parallel and Radial protocols which can be linked to a special series.

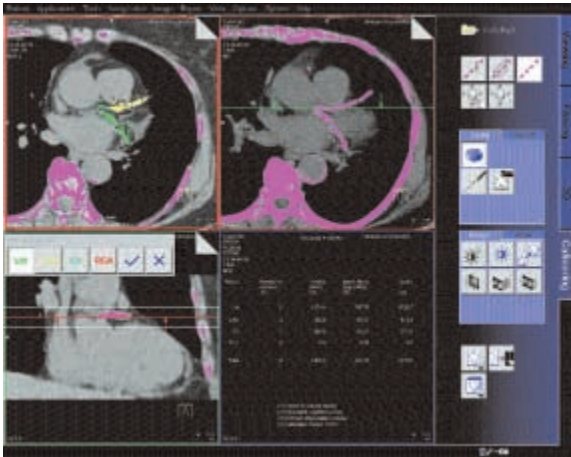
For example, if you always do MIP Reconstructions a Coronary CTA examination, you load once the images into the 3D card. Select the image type (e. g. MIPthin) and the orientation, and then open the Range Parallel function. Adapt the range settings (Image thickness, Distance between the images etc.), hit the link and save button. From this point on, you have a predefined post-processing protocol, linked to the series description of a coronary CTA examination.

Exactly the same can be done for VRT presets. In the main menu, under Type/VRT Definition, you can link and save VRT presets with a series description.

Some of the Scan protocols are preset with links to a postprocessing protocol. If you prefer to set your own presets, please delete the Range Parallel preset or overwrite them with your own settings.

Calcium Scoring evaluation is performed on a separate *syngo* task card:

1. The threshold of 130 HU is applied for score calculation by default, however, you can modify it accordingly.
2. In addition to the seeding method, you can use freehand ROI for the definition of lesions.
3. The separation and modification of lesions within a defined volume (depth in mm) can be performed not only on 2D slices, but also with 3D editing.
4. For easier identification of small lesions, you can blowup the display with a doubleclick.
5. You can customize hospital/office information on the final report using Report Configuration.
6. You can generate HTML report including site specific information, free text and clinical images. This then can be saved on floppy disc and/or printed.
7. The results are displayed online in a separate segment including the following information:
 - Number of lesions
 - Area (in mm^3)
 - Peak density (in HU)
 - Volume (in mm^3)
 - Calcium mass (mg calcium Hydroxyapatite)
 - Score (Agatston method)
8. The results can be printed on laser film, paper printer or saved into data base.



User interface of syngo Calcium Scoring

The Basics

The administration of intravenous (IV) contrast material during spiral scanning improves the detection and characterization of lesions, as well as the opacity of vessels. The contrast scan will yield good results only if the acquisition occurs during the optimal phase of enhancement in the region of interest. Therefore, it is essential to initiate the acquisition with the correct start delay. Since Multislice spiral CT can provide much faster speed and shorter acquisition time, it is even more critical to get the right timing to achieve optimal results (Fig. 1a, 1b).

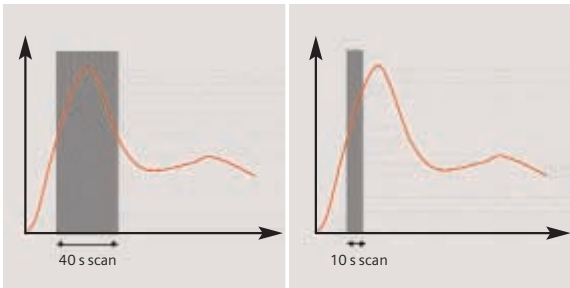


Fig. 1a: Longer scan time Fig. 1b: Shorter scan time

The dynamics of the contrast enhancement is determined by:

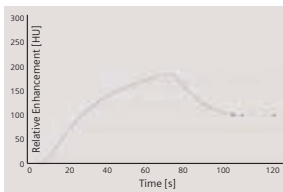
- Patient cardiac output
- Injection rate (Fig. 2a, 2b)
- Total volume of contrast medium injected (Fig. 3a, 3b)
- Concentration of the contrast medium (Fig. 3b, 4a)
- Type of injection – uni-phasic or bi-phasic (Fig. 4a, 4b)
- Patient pathology

Bolus Tracking

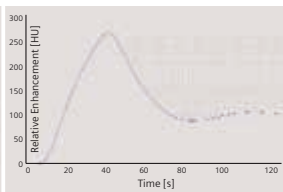
Aortic time-enhancement curves after i.v. contrast injection (computer simulation*).

All curves are based on the same patient parameters (male, 60-year-old, 75 kg).

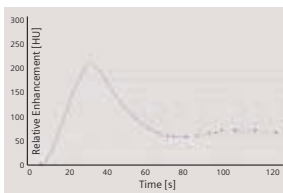
* *Radiology* 1998; 207:647-655



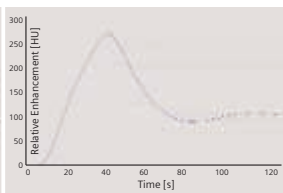
*Fig. 2a: 2 ml/s,
120 ml, 300 mg I/ml*



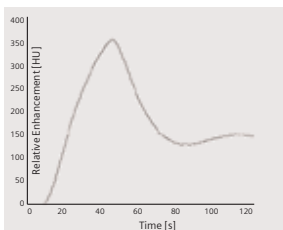
*Fig. 2b: 4 ml/s,
120 ml, 300 mg I/ml*



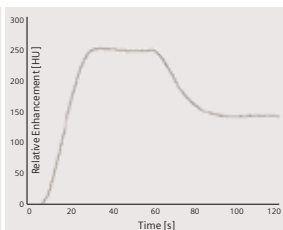
*Fig. 3a: 80 ml,
4 ml/s, 300 mg I/ml*



*Fig. 3b: 120 ml,
4 ml/s, 300 mg I/ml*



*Fig. 4a: Uni-phase
140 ml, 4 ml/s,
370 mg I/ml*



*Fig. 4b: Bi-phase
70 ml, 4 ml/s, plus 70 ml,
2 ml/s, 370 mg I/ml*

How to do it

To achieve optimal results in contrast studies, the use of CARE Bolus is recommended. In case it is not available, use Test Bolus. Once completed, load images into Dynamic Evaluation for calculation of Time to Peak enhancement.

CARE Bolus

This is an automatic bolus tracking program, which enables triggering of the spiral scanning at the optimal phase of the contrast enhancement.

General Hints:

1. This mode can be applied in combination with any spiral scanning protocol. Simply insert "Bolus tracking" by clicking the right mouse button in the chronicle. This inserts the entire set up including pre-monitoring, i.v. bolus and monitoring scan protocol. You can also save the entire set up as your own scan protocols (please refer to the application guide for routine protocols).
2. The pre-monitoring scan is used to determine the level of monitoring scans. It can be performed at any level of interest. You can also increase the mAs setting to reduce the image noise when necessary.
3. To achieve the shortest possible spiral start delay (2 s), the position of the monitoring scans relative to the beginning of spiral scan must be optimized. A "snapping" function is provided:

Bolus Tracking

- After the Topogram is performed, the predefined spiral scanning range and the optimal monitoring position will be shown.
 - If you need to redefine the spiral scanning range, you should also reposition the monitoring scan in order to keep the shortest start delay time (2 s). (The distance between the beginning of the spiral scanning range and the monitoring scan will be the same).
 - Move the monitoring scan line **towards** the optimal position and release the mouse button, it will be snapped automatically. (Trick: if you move the monitoring scan line **away** from the optimal position the “snapping” mechanism will be inactive).
4. Place an ROI in the premonitoring scan on the target area or vessel used for triggering with one left mouse click. (The ROI is defined with double circles – the outer circle is used for easy positioning, and the inner circle is used for the actual evaluation). You can also zoom the reference image for easier positioning of the ROI.
 5. Set the appropriate trigger threshold, and start contrast injection and monitoring scans at the same time.
During the monitoring scans, there will be simultaneous display of the relative enhancement of the target ROI. When the predefined density is reached, the spiral acquisition will be triggered automatically.
 6. You can also initiate the spiral any time during the monitoring phase manually – either by pressing the START button or by left mouse clicking the START radio button key. If you do not want to use automatic triggering, you can set your trigger threshold number extremely high so that it will not trigger automatically, and you can start the spiral when you desire.

TestBolus

Indications:

This mode can be used to test the start delay of an optimal enhancement after the contrast medium injection.

	TestBolus
<i>kV</i>	120
<i>Effective mAs</i>	30
<i>Slice collimation</i>	5.0 mm
<i>Slice width</i>	10.0 mm
<i>Feed/Scan</i>	0 mm
<i>Rotation time</i>	0.5 sec.
<i>Kernel</i>	B40f
<i>Cycle time</i>	2 sec.

Bolus Tracking

Application procedures:

1. Select the spiral mode that you want to perform, and then "Append" the TestBolus mode under **Special** protocols.
2. Insert the Test Bolus mode above the spiral mode for contrast scan by "cut/paste" (with right mouse button).
3. Perform the Topogram, and define the slice position for TestBolus.
4. Check the start delay, number of scans and cycle time before loading the mode.
5. A test bolus with 10-20 ml is then administered with the same flow rate as during the subsequent spiral scan. Start the contrast media injection and the scan at the same time.
6. Load the images into the Dynamic Evaluation function and determine the time to the peak enhancement.

Alternatively, on the image segment, click "select series" with the right mouse button and position an ROI on the first image. This ROI will appear on all images in the test bolus series. Find the image with the peak HU value, and calculate the time "delta t" taken to reach the peak HU value (do not forget to add the preset start delay time). This time can then be used as the optimal start delay time for the spiral scan.

Additional Important Information

1. The preset start delay time for monitoring scans depends on whether the subsequent spiral scan will be acquired during the arterial phase or venous phase. The default value is 10 s. You can modify it accordingly.
2. It should be pointed out that when using "Test Bolus", there may be residual contrast in the liver and kidneys prior to scanning. This may result in an inaccurate arterial and equilibrium phase.
3. The trigger threshold is not an absolute value but a relative value compared to the non-contrast scan. E. g. if the CT value is 50 HU in the non-contrast image, and your trigger level is 100 MU, then the absolute CT value in the contrast image will be 150 HU.
4. If you change slice collimation, rotation time or kV in the spiral scanning protocol after CARE Bolus is inserted, a longer spiral start delay time will be the result, e. g. 14 s. This is due to the necessary mechanical adjustments, e. g. moving the slice collimators. Therefore, it is recommended that you modify the parameters of the spiral scanning **before** inserting the CARE Bolus.

5. If API is used in conjunction with CARE Bolus, the actual start delay time for the spiral will be as long as the length of API including the predefined start delay time. E. g. if the predefined the start delay is 2 s, and the API lasts 5 s, the spiral will start 5 s after the threshold is reached.
6. In case you have to interrupt the monitoring scanning due to injection problem, you can repeat it afterwards by inserting CARE Bolus again with a right mouse click. The same Topogram can still be used.

Dental CT

This is an application package for reformatting panoramic views and paraxial slices through the upper and lower jaw. It enables the display and measurement of the bone structures of the upper and lower jaw (especially for a 1:1 scale) as the basis for OR planning in oral surgery.

The Basics

What is the relevant anatomical information for oral surgery planning and dental implantation?

- Location of the socket for dental implant
- Buccal and lingual thickness of the cortical component of the alveolar process
- Position of the mandibular canal and the mental foramen
- Extent of the nasal sinuses and position and width of the floor of the nasal cavity.

What can Dental CT do?

- Reformatting of a curvilinear range of panoramic views along the jaw-bone.
- Reformatting of paraxial views of selectable length and at selectable intervals perpendicular to the panoramic views.
- Presentation of results in the form of multiple image display with reference markings.
- Images are documented on film in "real-size" so that the direct measurement of the anatomic information with a ruler is possible. The layout of the film sheet is predefined such that it can accommodate the maximum number of reformatted images.

Dental CT

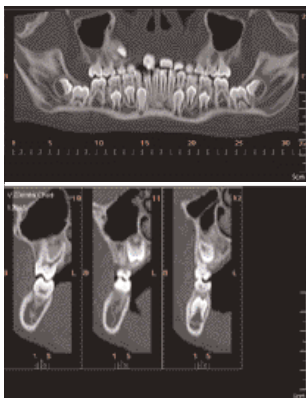


Fig. 1:
Panoramic view

Fig. 2:
Paraxial view

How to do it

Scan Protocol

A typical scan range of 5 cm can be done in 8.4 s.

	Dental
kV	120
Effective mAs	80
Slice collimation	0.75 mm
Slice width	0.75 mm
Feed/Rotation	5.0 mm
Rotation time	0.75 sec.
Kernel	H60s
Increment	0.5 mm
Image order	cr-ca
CTDI _{Vol}	16.9 mGy
Effective dose	Male: 0.3 mSv Female: 0.3 mSv

Dental CT

- It is mandatory to position the patient head in the center of the scan field – use the lateral laser light marker for positioning.
- Gantry tilt is not necessary since you have the possibility to tilt the reference line to generate an axial reformatted image at the desired plane. However, in order to minimize the scan length for the same anatomical region, it is recommended to position the patient's head at the appropriate scan plane whenever possible:
 - For the upper and lower jaw: occlusal plane in parallel to the scan plane.
 - For either jaw: jaw bone in parallel to the scan plane.
- It is recommended to end the exam first, and then start the Dental evaluation.

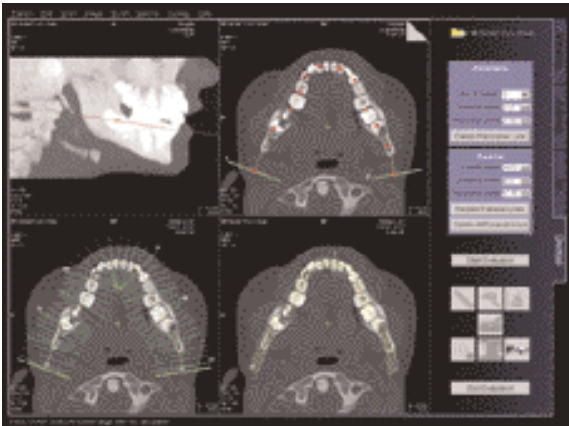


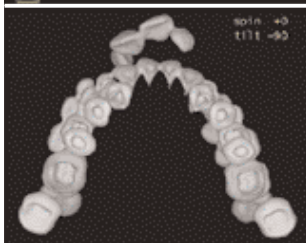
Fig. 3: User interface of syngo Dental

Additional Important Information

- This protocol delivers high resolution images for Dental CT evaluation, however, you can also reconstruct images with softer kernel, e. g. H20s, for 3D/SSD postprocessing.



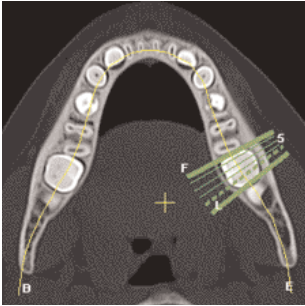
*Fig. 4a:
AP-cranial view*



*Fig. 4b:
Caudal view*

- Image orientation:
 - In the paraxial view, a “B” indicates buccal and a “L” lingual. The lingual marker “+” must always be positioned at the tongue. If not, simply drag & drop it back.
 - In the panoramic view, a “B” stands for “Begin” and an “E” for “End”.
- Filming: for the maximum use of the film, film directly from the Dental Card instead of Patient Browser. For easy reprinting, the results of the latest Dental CT Film are stored in the Patient Browser in the folder “Film”.
- It is better to change the image windowing on the virtual film sheet.
- A semi-automatic detection tool can be used to mark and outline the mandibular canal on both paraxial and panoramic images for easy viewing and filming.

- Multiple paraxial ranges can be defined on one reference image by "cluster & copy function". I. e., you can group a number of paraxial lines and copy the lines to another location, e. g. over individual sockets at different locations (Fig.5).
- ROI definition for statistical evaluations and deletion of graphics are possible.



*Fig. 5
Paraxial lines using
"Cluster".*

Osteo CT

This is an application package for the quantitative assessment of vertebral bone mineral density for the diagnosis and follow-up of osteopenia and osteoporosis.

The Basics

This program enables the quantitative determination of bone mineral density of the spine in mg/ml of calcium hydroxyapatite (CaHA) for the diagnosis, staging, and follow-up of osteopenia and osteoporosis with CT. The patient is scanned together with the water- and bone-equivalent calibration phantom.

What is "T-score"?

This is the deviation of average BMD of the patient from that of a young healthy control. It represents bone loss with reference to the peak bone mass.

What is "Z-score"?

This is the deviation of average BMD of the patient from that of a healthy person of the same age. It is an indicator of biological variability.

Siemens Reference Data:

The Siemens reference data was acquired at three European centers, including 135 male and 139 female subjects, 20 to 80 years of age.

How to do it

	Osteo
<i>kV</i>	80
<i>Effective mAs</i>	125
<i>Slice collimation</i>	5.0 mm
<i>Slice width</i>	10 mm
<i>Feed/Scan</i>	0 mm
<i>Rotation time</i>	0.5 sec.
<i>Kernel</i>	S80f
<i>Image order</i>	cr-ca
<i>CTDI_w</i>	2.5 mGy
<i>Effective dose</i>	Male: 0.02 – 0.03 mSv Female: 0.03 – 0.04 mSv

	OsteoObese
<i>kV</i>	80
<i>Effective mAs</i>	350
<i>Slice collimation</i>	5.0 mm
<i>Slice width</i>	10 mm
<i>Feed/Scan</i>	0 mm
<i>Rotation time</i>	1.5 sec.
<i>Kernel</i>	S80s
<i>Image order</i>	cr-ca
<i>CTDI_w</i>	7.0 mGy
<i>Effective dose</i>	Male: 0.07 mSv Female: 0.07 – 0.2 mSv

Osteo CT

Patient positioning:

- Set the table height at 125. The gantry tilt will be available from -22° to $+22^{\circ}$.
- Patients should be positioned so they are as parallel to the patient table as possible. Support the knees to compensate for lordosis.
- The calibration phantom should be positioned directly below the target region. Put the Gel-pad between the calibration phantom and the patient to exclude air pockets.

Scanning:

- Typically, one scan each is performed at L1, L2 and L3 levels. It is recommended to use image comments L1, L2, L3 prior to scanning. These comments will be displayed with the Osteo evaluation results.
- Before ending the examination, you can drag & drop the chronicle recon boxes to the topogram segment to get the Topographics, i. e. the cut lines for each vertebra on the topogram.
- Select the appropriate scan protocol according to the patient size, i. e. use "OsteoObese" for obese patient.
- Position the cut line of scanning through the middle of the vertebra, i. e. bi-sector between the angle of the upper and lower end plate.
- The phantom must be included in the FoV of the images for evaluation.
- It is recommended to end the exam first, and then start the Osteo evaluation.

Note: It is not recommended to use a vertebra with noticeable pathology on the topogram for osteo evaluation.

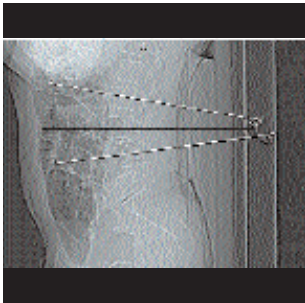


Fig. 1:
Topographic

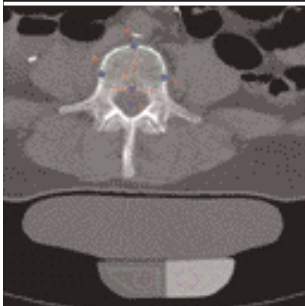


Fig. 2:
Phantom inside
the FoV

Additional Important Information

- Fractured vertebrae are not suited for Osteo CT evaluation since the more compact nature of these vertebrae result in bone mineral density value that is much higher than one would expect.
- How to save the results on your PC?
 - Select Option/Configuration from the main menu and click icon "CT Osteo".
 - Activate the checkbox "Enable Export of Results".
 - "Exit" the configuration dialog.
 - Call up the Osteo card and you will see the new icon "Export results" on the lower, right part of the screen.
 - Click this icon to copy the evaluation results to floppy disk (Note: with every mouse click on the icon, the previous result file will be appended).
 - The data file can be transferred to your PC for further evaluation, e. g. with MS Excel.

Note: for detailed information about the data file, please refer to the Appendix.

- It is recommended to film directly from the Osteo card. Select images or series with Edit/Select all, and click "film" icon. You can also configure film layout, e. g. 3 x 3 as shown in figure 3 in Option/Configuration/FilmingLayout.



Fig. 3: Filming layout

Note: it is not recommended to use filming setting of 4 x 5 segments since the image text elements of the result image are overlapped and hard to read.

Pulmo CT

This is an application package, which serves for quantitative evaluation of the lung density to aid the diagnosis and follow-up of diffuse lung diseases, such as pulmonary emphysema, sarcoidosis, pan-bronchiolitis and silicosis.

The Basics

- No specific scan protocols were set up for this option. Scan protocols for routine thorax imaging can be used. The scan parameters used are dependent on the indications and objectives of the study design. For example, spiral mode for lung volume evaluation or HR sequence mode for interstitial lung diseases.
- Lung density is influenced by respiratory status (Fig.1).

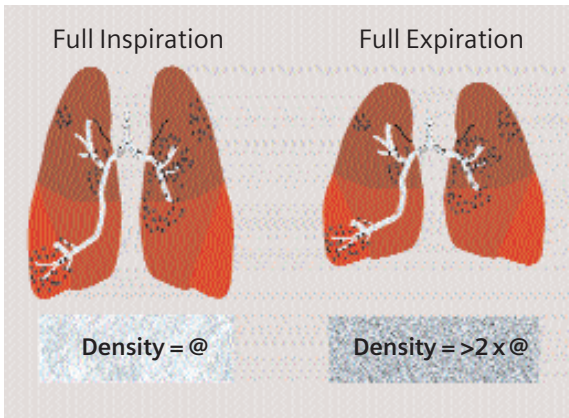


Fig. 1: Lung density at full inspiration/expiration

- Examinations should be acquired at the same respiratory level, usually at either full inspiration or full expiration. Studies had shown that reproducibility is high and is unlikely to be improved by using spirometric gating [1].

Literature

1. Repeatability of Quantitative CT Indexes of Emphysema in Patients Evaluated for Lung Volume Reduction Surgery. David s. Gierada et al, Radiology 2001 220: 448-454

Siemens Reference Data

This reference data was acquired from lung healthy individuals at 50% vital capacity. Since Pulmo CT program does not provide spirometric triggering for the acquisition of the data set, it is not meaningful to use Siemens reference data for comparison unless the data is acquired under the same conditions.

User-Specific Reference Data

It is possible to integrate in your own reference data, e. g. data acquired at full inspiration, for the evaluation. Please contact the local Siemens representative for further information.

How to do it

It is recommended to end the exam first, and then start the Pulmo evaluation.

Select the images that you want to evaluate, and activate the program by clicking on the "Pulmo" icon.

Additional Important Information

- How to export the evaluation results to a floppy disc?
 - Select Option/Configuration from the main menu and click icon “Pulmo”.
 - Activate the checkbox “Enable Export of Results”.
 - “Exit” the configuration dialog.
 - Call up the Pulmo card and you will see the new icon “Export results” on the lower, right part of the screen.
 - Click this icon to copy the evaluation results onto floppy disk. (Note: with every mouse click on the icon, the previous result file on the floppy will be appended).
 - The data file can be transferred to your PC for further evaluation, e. g. with MS Excel.
Note: for detail information about the data file, please refer to the Appendix.
- Standard and expert mode can be configured to your needs.
 - Select Option/Configuration/Pulmo.
For example, if you want to determine the percentage area of the lung within a specific HU range, use the card “Subranges” on the Configuration/Pulmo dialog.
- Color-coded display of HU subranges and percentiles is possible. This allows direct visualization of the different densities distribution within the lung.
- The auto-contour detection can be used as editing function for 3D postprocessing of lung images.

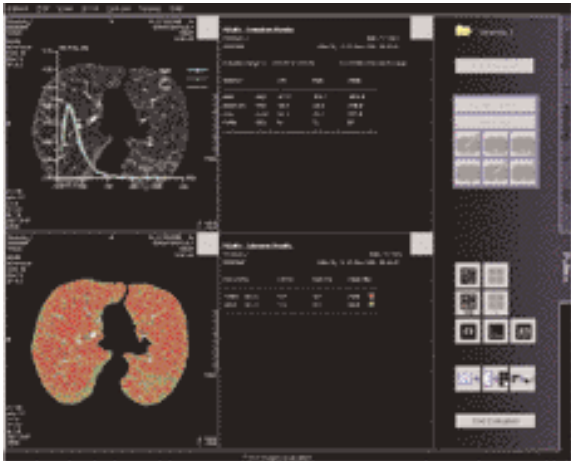


Fig. 2: User interface of syngo Pulmo

Perfusion CT

This is an application software package for the quantitative evaluation of dynamic CT data of the brain following injection of a highly concentrated iodine contrast bolus. The main application is in the differential diagnosis and management of acute ischemic stroke.

The Basics

- The software optimally supports the stringent time and workflow requirements in an emergency setting where time is brain.
- Parameters generated include among others cerebral blood flow (CBF), cerebral blood volume (CBV), the time to local perfusion onset (Time-to-Start) and the time to local perfusion peak (Time-to-Peak).

Example: A 44-year-old man was brought to the hospital about 2 hours after the start of severe neurological symptoms of stroke in the right hemisphere.

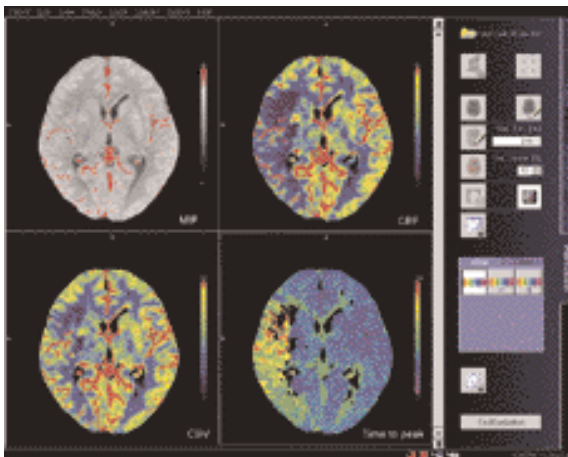


Fig. 1: User interface of syngo Perfusion

The CBF image shows a severe perfusion disturbance (flow close to zero) in the insular cortex and the posterior portion of the lentiform nucleus. In comparison to the left hemisphere the remaining supply area of the middle cerebral artery shows moderately reduced flow.

- The CBV image shows the same severe reduction in insular cortex and lentiform nucleus. In contrast to the CBF image, however, the blood volume in the remaining right MCA territory is close to normal, if it is compared to the same area on the left side.
- The time-to-peak image shows a general prolongation of values in the MCA territory indicating delayed bolus arrival.

How to do it

Scan protocols

There are two Scan protocols available:

BrainPerfCT, a non contrast study and a Multiscan with 12 mm collimation and 2 times a 12 mm slice thickness.

BrainPerfSingle, a non contrast study and a Multiscan with 5.0 mm collimation and one 10 mm slice thickness.

BrainPerfCT	NonContrast	Multiscan
<i>kV</i>	120	80
<i>Effective mAs</i>	320	209
<i>Slice collimation</i>	3.0 mm	12.0 mm
<i>Slice width</i>	9.0 mm	12.0 mm
<i>Feed/Scan</i>	18 mm	
<i>Feed/Rotation</i>		0.0 mm
<i>Rotation time</i>	1.0 sec.	1.0 sec.
<i>Cycle time</i>	3.0 sec.	
<i>Kernel</i>	H30s	H30s
<i>Increment</i>		1.0
<i>Image order</i>	ca-cr	ca-cr

BrainPerfSingle	NonContrast	Multiscan
<i>kV</i>	120	80
<i>Effective mAs</i>	320	250
<i>Slice collimation</i>	3.0 mm	5.0 mm
<i>Slice width</i>	9.0 mm	10.0 mm
<i>Feed/Scan</i>	18 mm	
<i>Feed/Rotation</i>		0.0 mm
<i>Rotation time</i>	1.0 sec.	1.0 sec.
<i>Cycle time</i>	3.0 sec.	
<i>Kernel</i>	H30s	H30s
<i>Increment</i>		1.0
<i>Image order</i>	ca-cr	ca-cr

Such a standard protocol may be slightly modified for specific reasons; e. g. the start delay can be increased by a few seconds for patients with very low cardiac output.

Perfusion CT

IV injection protocol	
Contrast medium	Non-ionic
Concentration	300 – 370 mg/ml
Injection rate	8 ml/sec.
Total volume	40 ml
Total injection time	~ 5 sec.
Start delay time	4 sec

The technique requires a short bolus. The original studies were performed mostly using 50 ml injected at 10 ml/s.

The routine application has shown, that by sacrificing some of the spatial resolution, the examination can also be done with smaller amounts of contrast (35 to 40 ml) and correspondingly smaller flow rates. The smaller the total amount the more helpful it is to consider a saline chaser bolus. In any case, a state-of-the-art power injector is recommended.

If a flow rate of 8 ml/s is considered not recommendable for a specific patient, the protocol can be reduced to 40 ml at 5ml/s. Image quality will be reduced but the technique will still be diagnostic.

- Additional measures to facilitate the injection, like using a large gauge cannula (16 or 18 are usually sufficient) and warming the contrast media to body temperature to reduce its viscosity, should be considered.

Note: As with any contrast medium application, verify that the particular models and brands that you use in the chain injector/contrast medium/cannula are approved by their respective manufactures for the use with the parameters you select.

- Motion during acquisition must be avoided. Therefore, if at all possible you should try to explain the course of the examination to the patient and use additional head fixation in any case.

Perfusion CT

- The standard examination slice is best positioned such that it cuts through the basal ganglia at the level of the inner capsule. This selection includes those vascular territories of the brain that are frequently affected by perfusion impairment associated with acute stroke in the carotid territory.
- The slice should be selected “flatter” than in normal head CT scan, the angulation should be adjusted perpendicular to the occipital segment of the superior sagittal sinus well above the confluence of sinuses.
- The eye lens should never be positioned in the scan plane.



Example of a standard slice through the basal ganglia in a lateral topogram.

Additional Important Information

1. Why short injection times are necessary?

The brain has a very short transit time (approx. 3 to 5 seconds) and a relatively small fractional blood volume (approx. 2 to 5%). This requires a compact bolus for optimal time resolution and a certain minimum amount of contrast for optimal signal to noise ratio. Bolus definition can be significantly improved and the amount of contrast necessary reduced by using a saline chaser bolus with the same flow rate directly following the CM injection.

2. What do normal, contrast-enhanced and Perfusion CT images show?

In order to interpret Perfusion CT images correctly, it is essential to understand that they are “functional” or “parameter” images that display a different type of information than standard CT images: Normal CT images basically show only morphological properties of tissues by displaying their x-ray attenuation relative to that of water as CT-values in HU-units.

Standard contrast-enhanced CT extends this limitation either to make a compartment visible that normally has low contrast (e. g. vascular structures in CTA) or to qualitatively display major perfusion differences of tissues (e. g. tumors or multiphase liver studies).

Perfusion CT tries to utilize all the information hidden in the temporal changes of contrast enhancement by fitting a mathematical model to the local time attenuation curves. For each voxel this process yields a variety of numbers which describe different aspects of tissue perfusion. As the human eye is so much faster and better suited to interpret images than large amounts of numbers it makes sense to display these quantities in the form of images.

3. What do pixel values mean in the Perfusion CT images?

It is very important to realize that pixel values now have a different meaning, which depends on the type of image currently displayed. So if you point the cursor into a parameter image bear in mind that you do not read a CT-value but a functional unit. A time-to-peak image, for example, displays numbers proportional to the time until the bolus peak is reached; so higher numbers mean later bolus arrival.

A CBF image, on the other hand, displays numbers proportional to blood flow; so smaller numbers indicate lower flow.

4. Filming color images

If a color hardcopy device is connected to the system, color images can be printed via the filming task card. It is recommended to send the color images from the Viewing task card after having saved them on the Perfusion task card.

5. How to fine-tune the color mapping?

– For “flow images” (CBF and CBV) – the color palette for the flow image is designed such, that after optimal adjustment with the arrow buttons the following approximate correspondence will result for a normal brain:

red _ vessels

green/yellow _ gray matter

blue _ white matter

black _ no calculation (CSF space)

After adjustment (use non-ischemic hemisphere as guideline) ischemic areas will therefore be displayed either in violet (very low flow) or as a mismatch with the nonischemic side (gray matter is blue instead of green).

– For “Time images” (Time to Start and Time to Peak) – the color palette for the time images maps increasing time values on a spectral scale:

Violet _ blue _ green _ yellow _ red

Display should be adjusted with the arrow buttons such that the areas with latest arrival times are just slightly red. As with the flow image black means no calculation (CSF space, or areas with extremely low flow – no time assessment possible).

Dynamic Scanning

These are protocols templates for the analysis of contrast enhancement dynamics in the body. Scan parameter details such as mAs, slice width, increment etc. depend on the organ to be studied.

These may be used with the Dynamic Evaluation function for the descriptive analysis of contrast enhancement of tissues.

Scan Protocols

There are three scan protocols available:

BodyDynCT, a Serio Mode with a 12 mm slice collimation and 2 times a 12 mm slice width.

BodyDynSingle, a Serio Mode with a 5 mm slice collimation and one 10 mm slice width.

BodyPerfCT, a Multiscan with a 12 mm slice collimation and 2 times a 12 mm slice width.

Dynamic Scanning

BodyDynCT	DynSerio	DynSerio
<i>kV</i>	120	
<i>Effective mAs</i>	100	
<i>Slice collimation</i>	12.0 mm	
<i>Slice width</i>	12.0 mm	
<i>Feed/Scan</i>	0 mm	
<i>Rotation time</i>	0.5 sec.	
<i>Cycle time</i>	1.0 sec.	5.0 sec.
<i>Kernel</i>	B30f	

BodyDynSingle	DynSerio	DynSerio
<i>kV</i>	120	
<i>Effective mAs</i>	100	
<i>Slice collimation</i>	5.0 mm	
<i>Slice width</i>	10.0 mm	
<i>Feed/Scan</i>	0 mm	
<i>Rotation time</i>	0.5 sec.	
<i>Cycle time</i>	1.0 ec.	5.0 sec.
<i>Kernel</i>	B30f	

BodyPerfCT	DynSerio
<i>kV</i>	120
<i>Effective mAs</i>	84
<i>Slice collimation</i>	12.0 mm
<i>Slice width</i>	12.0 mm
<i>Rotation time</i>	1.0 sec.
<i>Kernel</i>	B30s

Interventional CT

To facilitate CT interventional procedures, we created dedicated multislice and single slice sequential modes.

- Biopsy
This is the multislice biopsy mode. E. g. 6 slices, 3.0 mm each, will be reconstructed and displayed for each scan.
- BiopsyCombine
This is a single slice biopsy mode. 2 x 5 mm slice collimation is used to get a combined 10 mm slice.

The Basics

Any of these protocols can be appended to a spiral protocol for CT interventional procedures, such as biopsy, abscess drainage, pain therapy, minimum invasive operations, joint studies, and arthrograms.

10 scans are predefined. You can repeat it by clicking the chronicle with the right mouse button and select "repeat", or simply change the number of scans to 99 before you start the first scan.

You can "Append" any routine protocol after the interventional procedure for a final check and documentation, e. g. a short range of spiral scanning for the biopsy region.

The table height can be adjusted to minimum 255 mm.

How to do it

Biopsy

Indications: This is the multislice biopsy mode. 6 slices, 3.0 mm each, will be reconstructed and displayed for each scan. It can be appended to any other scan protocol, e. g. ThoraxRoutine for biopsy procedures in the thorax. Change the mAs setting accordingly before you load the mode.

	Biopsy
<i>kV</i>	120
<i>Effective mAs</i>	120
<i>Slice collimation</i>	3.0 mm
<i>Slice width</i>	3.0 mm
<i>Feed/Scan</i>	0 mm
<i>Rotation time</i>	0.5 sec.
<i>Kernel</i>	B30f



Application procedures:

1. Perform a spiral scan first to define a target slice.
2. Click "Same TP" under Table position in the routine card, and move the table.
3. Turn on the light marker to localize the Entry point, and then start the patient preparation.
4. Select "Biopsy" mode under Special protocols, and then click "Append".

Interventional CT

5. Click "Load" and then "Cancel move". Press the "Start" button and 6 images will be displayed.
6. Press "Start" again, you'll get another 6 images with the same slice position.

BiopsyCombine

Indications: This is the biopsy mode with one combined slices. It can be appended to any other scan protocol, e. g. ThoraxRoutine for biopsy procedures in the thorax.

Change the mAs setting accordingly before you load the mode.

	BiopsyCombine
<i>kV</i>	120
<i>Effective mAs</i>	120
<i>Slice collimation</i>	5.0 mm
<i>Slice width</i>	10 mm
<i>Feed/Scan</i>	0 mm
<i>Rotation time</i>	0.5 sec.
<i>Kernel</i>	B30f

Application procedures:

1. Perform a spiral scan first to define a target slice.
2. Click "Same TP" under Table position in the routine card, and move the table.
3. Turn on the light marker to localize the Entry point, and then start the patient preparation.
4. Select "BiopsyCombine" mode under Special protocols, and then click "Append".
5. Click "Load" and then "Cancel move". Press the "Start" button and one image will be displayed.
6. Press "Repeat" and "Start" again, you'll get another image with the same slice position.

Additional Important Information

- In the BiopsyCombine mode, the slice position, table position, table begin and table end are all the same.
- In the Biopsy mode, the slice position, table position, table begin and table end are different.

a) The SP (slice position) in each image means the center of the image (Fig. 1).

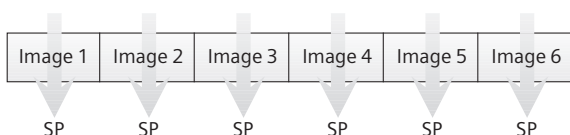


Fig. 1

b) The "Table position" means the central position of the 6 images and will also be the position of the positioning light marker (Fig. 2).

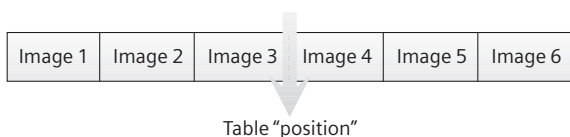


Fig. 2

c) The table "Begin" means the center of the first image, and the table "End" means the center of the last image (Fig. 3).



Fig. 3

Trauma

In any trauma situation, time means life and the quality of life for the survivor. In order to facilitate the examinations, two protocols are provided:

- Trauma
This is a one-range mode for fast screening
- PolyTrauma
This is a combined mode for the examination of multiple ranges, e. g. Head, Neck, Thorax, Abdomen and Pelvis

The Basics

- Check that the emergency drug trolley is well-stocked and that all accessories such as in-room oxygen supply, respirator and resuscitation equipment that may be required during the examination are in working order.
- Prepare the CT room before admitting the patient, e. g., load IV contrast into the injector.
- Know, observe and practice the standard hospital operating policy for handling a patient in distress e. g. Code Blue for cardiac and respiratory arrest.
- Any possible injuries to the spinal column should be determined before beginning the examination and taken into account when shifting and positioning the patient.
- Ensure that all vital lines e. g., IV tubing and oxygen tubing are not trapped under the patient or between the table and the cradle. Make allowance for the length of tubing required for the topogram scan range.

Trauma

- Never leave patients unattended at any time during the procedure.
- Observe the vital signs e. g. ECG, respiration, etc. at all times during the procedure.
- Finish the examination in the shortest possible time.

How to do it

Trauma

Scan Protocol

A scan range of 50.4 cm can be done in 17.4 s.

	Trauma
<i>kV</i>	120
<i>Effective mAs</i>	140
<i>Slice collimation</i>	1.5 mm
<i>Slice width</i>	7.0 mm
<i>Feed/Rotation</i>	15.0 mm
<i>Rotation time</i>	0.5 sec.
<i>Kernel</i>	B31f
<i>Increment</i>	7.0 mm
<i>Image order</i>	cr-ca
<i>CTDI_{Vol}</i>	10.5 mGy

You can adjust the mAs setting according to the region to be examined.

Trauma

PolyTrauma

Scan Protocol

A scan range of head is 11 cm and will be done in 8,7 s.

A typical scan range of for neck is 15 cm and will be done in 6,9 sec.

PolyTrauma	HeadFast	NeckFast
<i>kV</i>	120	120
<i>Effective mAs</i>	260	150
<i>Slice collimation</i>	1.5 mm	1.5 mm
<i>Slice width</i>	6.0 mm	5.0 mm
<i>Feed/Rotation</i>	10.5 mm	12.0 mm
<i>Rotation time</i>	0.75 sec.	0.5 sec.
<i>Kernel</i>	H31s	B31f
<i>Increment</i>	6.0 mm	5.0 mm
<i>Image order</i>	ca-cr	cr-ca
<i>CTDI_{Vol}</i>	49.1 mGy	11.3 mGy
<i>Effective dose</i>	Male: 1.6 mSv Female: 1.7 mSv	Male: 1.6 mSv Female: 1.7 mSv

A scan range of thorax is 25 cm and will be done in 7.5 sec.

A typical scan range of a abdomen with pelvis is 40 cm and will be done in 11.7 sec.

PolyTrauma	ThoraxFast	AbdPelRoutine
<i>kV</i>	120	120
<i>Effective mAs</i>	110	160
<i>Slice collimation</i>	3.0 mm	3.0 mm
<i>Slice width</i>	7.0 mm	7.0 mm
<i>Feed/Rotation</i>	18.0 mm	18.0 mm
<i>Rotation time</i>	0.5 sec.	0.5 sec.
<i>Kernel</i>	B41f	B31f
<i>Increment</i>	7.0 mm	7.0 mm
<i>Image order</i>	cr-ca	cr-ca
<i>CTDI_{Vol}</i>	7.6 mGy	11.0 mGy
<i>Effective dose</i>	Male: 2.6 mSv Female: 3.4 mSv	Male: 6.6 mSv Female: 10.6 mSv

In different polytrauma cases, you could either combine different protocols, or delete any of the chronicles from the predefined protocol if they are not needed.

Additional Important Information

- For long range scanning, please pay attention to the mark of scannable range on the table mattress while positioning the patient.
- In some cases, it might be advisable to position the patient Feet first so that there will be more space for the intensive care equipment around.
- The Trauma protocol is predefined with a Topo length of 1024 mm, the Poly Trauma protocol with a Topo length of 1536 mm.

Note: You should press the “Hold Measurement” button whenever the range shown on the real time growing topogram is long enough, in order to avoid unnecessary radiation.

LungCARE

A dedicated low dose Spiral mode for the syngo LungCARE evaluation.

Indications:

Lung studies with low dose setting, e. g. early visualization of pulmonary nodules.

A typical thorax study in a range of 30 cm will be covered in 13.9 sec.

	LungCARE
<i>kV</i>	120
<i>Effective mAs</i>	20
<i>Slice collimation</i>	0.75 mm
<i>Slice width</i>	1.0 mm
<i>Feed/Rotation</i>	11.3 mm
<i>Rotation time</i>	0.5 sec.
<i>Kernel</i>	B50f
<i>Increment</i>	0.5 mm
<i>Image order</i>	cr-ca
<i>CTDI_{vol}</i>	1.6 mGy
<i>Effective dose</i>	Male: 0.6 mSv Female: 0.7 mSv

We recommend using a tube voltage of at least 120 kV.

For further information on the syngo LungCARE Application, please refer to the Application Guide "Clinical Options".

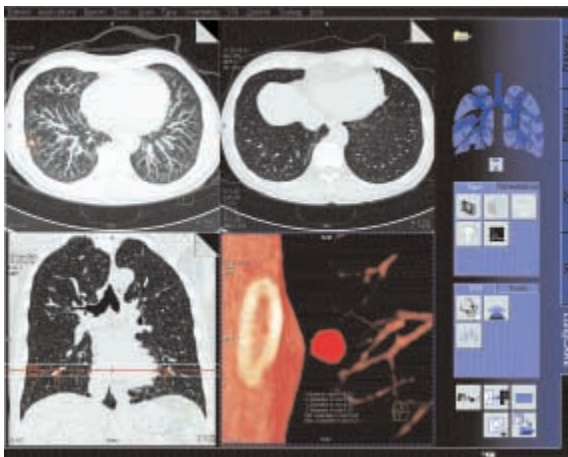


Fig. 1: User interface of syngo LungCARE

syngo LungCARE is a dedicated software for visualization and evaluation of pulmonary nodules using low-dose lung scanning and for subsequent follow-up studies.

Functionalities

- 3D Visualization with Thin Slabs using MPR, MIP and VRT displays.
- Computer-guided localization of pre-marked lesion.
- Close-up inspection of suspected lesion with the Rotating MPR mode.
- Automatic evaluation of pulmonary nodules with perspective VRT or MPR display.
- Automatic volume and diameter measurements of pulmonary nodules.
- Follow-up mode with synchronization of two data-sets.
- Easy and flexible reporting of the evaluated nodules.

Colonography

This is a promising application, dedicated to visualize and evaluate lesions in the colon. This study is not only non-invasive, but a much more comfortable method for the patient.

A typically range of 40 cm can be covered in 18.4 s.

	CT Colonography	2 nd reconstr.
kV	120	
Effective mAs	100	
Slice collimation	0.75 mm	
Slice width	5.0 mm	1.0 mm
Feed/Rotation	11.3 mm	
Rotation time	0.5 sec.	
Kernel	B30f	B30f
Increment	5.0 mm	0.7 mm
Image order	cr-ca	
CTDI _{Vol}	8.3 mGy	
Effective dose	Male: 4.8 mSv	Female: 8.2 mSv

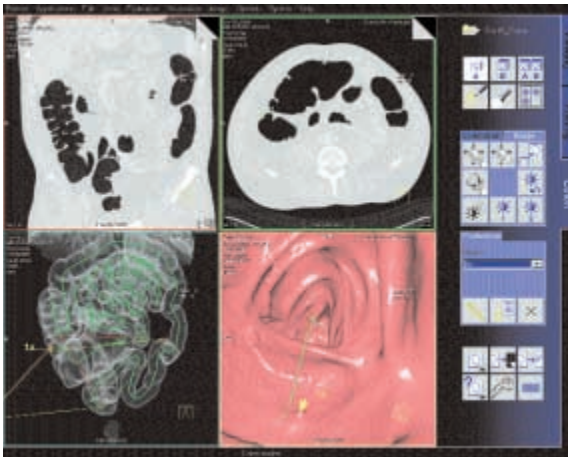


Fig. 1: User interface of syngo Colonography

Colonography

We recommend using a tube voltage of at least 120 kV.

A comprehensive study consists of four sections: Preparation, examination in supine & prone positioning and postprocessing.

- Patient preparation

In the case of CT Colonography, adequate preparation in bowel cleaning must be done prior to the CT examination.

The patient has to start with a diet and bowel cleansing two days prior to the examination like for a conventional Colonoscopy.

- Patient examination

The bowels can be delineated with air. Or, if desired, with carbon dioxide.

Inflate the colon to the patients maximum tolerance.

To decrease colon spasm, e. g. Buscopan™ or Glucagon™ can be given IV.

Usually a prone and supine examination are done to differentiate between polyps and stool within the colon. The second scan can be performed with lower dose, e. g. 30 to 50 mAs.

- Postprocessing

For further information on the *syngo* Colonography Application, please refer to the Application Guide "Clinical Options".

Osteo CT

Example for one patient with three Osteo tomograms:

PATIENT; John Smith; 007; 64; Male

IMAGE; L2; 234; 2; 27-JAN-1998; 11:12:17; 61.7; 48.9; 55.3; 20.8; 20.1; 21.5; 205.8; 192.0; 198.7; 50.6; 47.5; 49.5

IMAGE; L3; 236; 3; 27-JAN-1998; 11:12:18; 60.4; 54.5; 49.3; 22.3; 21.1; 21.8; 210.5; 191.9; 180.7; 50.4; 47.5; 52.3

IMAGE; L4; 238; 4; 27-JAN-1998; 11:12:18; 59.3; 43.1; 55.0; 20.6; 29.0; 23.3; 201.8; 178.1; 192.3; 43.6; 45.9; 44.2

REFDATA; 64; Male; 20; -4.35; -3.12; 75.4; 125.3; 26.5

Data Structure of the result file:

PATIENT; <Patient name>; <Patient ID>;

<Age of patient>; <Sex of patient>

IMAGE; <Vertebra name>; <Image number>;

<Scan number>; <Scan date>; <Scan time>; <TML>;

<TMR>; <TMT>; <TSL>; <TSR>; <TST>; <CML>; <CMR>;

<CMT>; <CSL>; <CSR>; <CST>

REFDATA; <Age of patient>; <Sex of patient>;

<Age of young normal>; <T-Score>; <Z-Score>;

<BMD reference data, age matched>;

<BMD reference data, young control>;

<Standard deviation reference data>

Appendix

Abbreviations:

TML Trabecular Mean Left

TMR Trabecular Mean Right

TMT Trabecular Mean Total

TSL Trabecular Standard Deviation Left

TSR Trabecular Standard Deviation Right

TST Trabecular Standard Deviation Total

CML Cortical Mean Left

CMR Cortical Mean Right

CMT Cortical Mean Total

CSL Cortical Standard Deviation Left

CSR Cortical Standard Deviation Right

CST Cortical Standard Deviation Total

Pulmo CT

Example of result file:

START; 20-FEB-1998 12:01:17
PATIENT; John Smith; 007; 64; Male
IMAGE; 234; 21; 27-JAN-1998 11:12:17;-200;1
RESULTS; LEFT; 234; -1024; 3071; -905; 43.4; 22.5;
112; 34.5; 0.1
RESULTS; RIGHT; 234; -1024; 3071; -899; 33.4; 19.5;
85; 30.1; 0.1
RESULTS; TOTAL; 234; -1024; 3071; -903; 38.1; 21.0;
93; 64.6; 0.1
SUBRANGE; LEFT; 234; 1; -1000; -400; 200; 75.0;
15.9; 3.3
SUBRANGE; RIGHT; 234; 1; -1000; -400; 200; 80.9;
15.1; 2.2
SUBRANGE; TOTAL; 234; 1; -1000; -400; 200; 78.0;
15.5; 2.8
SUBRANGE; LEFT; 234; 2; -1024; 1000; 0; 100.0
SUBRANGE; RIGHT; 234; 2; -1024; 1000; 0; 100.0
SUBRANGE; TOTAL; 234; 2; -1024; 1000; 0; 100.0
PERCENTILE; LEFT; 234; 1; 0; 100; 25; -1012; -954;
-953; -885; -884; -800; -799; -112
PERCENTILE; RIGHT; 234; 1; 0; 100; 25; -1023; -934;
-933; -888; -887; -785; -784; -211
PERCENTILE; TOTAL; 234; 1; 0; 100; 25; -1023; -944;
-943; -886; -885; -793; -793; -112
.....

Appendix

Data structure of the result file:

START; <Date and Time of the evaluation start>

PATIENT; <Patient name>; <Patient ID>;

<Age of patient>;

<Sex of patient>

IMAGE; <Image number>; <Scan number>;

<Scan date and time>; <Threshold Contour>;

<Number of Shrinkings>

RESULTS; <LEFT/RIGHT/TOTAL>; <Image number>;

<Lower eval. limit>; <Upper eval. limit>; <Mean>;

<Standard Deviation>; <Area>; <FWHM>;

<Accumulated Volume>; <Accumulated Height>

SUBRANGE; <LEFT/RIGHT/TOTAL>; <Image number>;

<Subrange Number>; <Lower Limit>; <Upper Limit>;

<Increment>; <Percent Area first subrange>;;

<Percent Area last subrange>

PERCENTILE; <LEFT/RIGHT/TOTAL>;

<Image number>; <Percentile range number>;

<Lower Limit>; <Upper Limit>; <Increment>;

<Lower HU value first percentile>;

<Upper HU value first percentile>;;

<Lower HU value last percentile>;

<Upper HU value last percentile>

AUTOSEGMENT; <LEFT/RIGH >;

<Image number>; <Segmentation number>;

<W=Whole/C=Central/P=Peripheral>;

<A=Area/H=Heights>; <Number of segments>;

<Distance>; <ROI width>;

<AP gradient : 0=no / 1=yes>;

<Mean value first segment>;;

<Mean value last segment>;

<Standard deviation first segment>;;

<Standard deviation last segment>;

<Area first segment>;; <Area last segment>;

<AP-Gradient>

Appendix

MANSEGMENT; <LEFT/RIGHT>;
<Image number>; <Segmentation number, always 1>;
<Number of segments>;
<Mean value first segment>;;
<Mean value last segment>;
<Standard deviation first segment>;;
<Standard deviation last segment>;
<Area first segment>;; <Area last segment>
TOTALRESULTS; <LEFT/RIGHT/TOTAL>;
<Upper eval. limit>; <Lower eval. limit>; <Mean>;
<Standard Deviation>; <Area>; <FWHM>;
<Accumulated Volume>; <Accumulated Height>
TOTALSUBRANGE; <PATIENT/REFERENCE/RATIO>;
<Subrange Number>; <Lower Limit>; <Upper Limit>;
<Increment>;
<Percent Area first subrange (or Ratio for RATIO)>;;
<Percent Area last subrange (or Ratio for RATIO)>
TOTALPERCENTILE;
<PATIENT/REFERENCE/DIFFERENCE>;
<Percentile range number>;
<Lower Limit>; <Upper Limit>; <Increment>;
<Lower HU value first percentile
(or difference for DIFFERENCE)>;
<Upper HU value first percentile
(or difference for DIFFERENCE)>;;
<Lower HU value last percentile
(or difference for DIFFERENCE)>;
<Upper HU value last percentile
(or difference for DIFFERENCE)>
REFDATA; <Age of patient>; <Sex of patient>;
<Age of young normal>; <T-Score>;
<Z-Score>; <Reference data, age matched>;
<Reference data, young control>;
<Standard deviation reference data>
END; <Date and Time of the evaluation end>

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