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CT PERFUSION 3

Quick Step Guide

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REVISON HISTORY

Revision	Date	Reason for change
0	June 03, 2003	2.6.0 M4 release

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CT PERFUSION 3 STEP BY STEP

Warning: The parameters and injection rates provided in this Quick Step Guide are strictly a guideline. The parameters should be reviewed by the physician or radiologist as part of the total patient work-up.

FEATURE DESCRIPTION

CT Perfusion 3 provides expanded protocols and capabilities for processing and displaying contrast enhanced time course data for perfusion exams for brain disturbance (stroke) and tumor in the brain and body. The Accurate Deconvolution algorithm is used to create functional maps for Brain Stroke, Brain Tumor, Body Tumor, Liver Tumor, Kidney, Prostate, Pancreas, Soft Tissue, Spleen and Bone protocols. For the perfusion examinations in the brain, a 2D image registration is included to minimize patient motion in the x and y planes. The User Interface has been updated to provide an easy to follow process to create, display and save functional maps for a wide range of organs.

FUNCTIONAL IMAGES

The **CT Perfusion 3** Protocols (**Brain Stroke**, **Brain Tumor**, **Body Tumor, Liver Tumor, Kidney, Prostate, Pancreas, Soft Tissue, Spleen and Bone**) provide the ability to create the following functional maps with quantitative information:

- Cerebral/Tumor Blood Volume – BV expressed in ml per 100 gram of wet tissue.
- Cerebral/Tumor Blood Flow – BF expressed in ml per 100 gram of wet tissue per minute.
- Mean Transit Time – MTT expressed in seconds.
- Permeability Surface - PS expressed in ml per 100 gram of wet tissue per minute. *(Tumor and organ protocols only)*.
  - Permeability (P) is related to the diffusion coefficient (D) of the contrast agent molecules through the pores in the capillary endothelium. Specifically, if the thickness of the endothelium is (t) then P is defined as P=D/t.
  - Surface area (S) is the total surface area of per-fused capillaries.
  - So, PS is the product of permeability and surface area and hence called the permeability surface area product.

  In physiological terms, PS multiplied by the arterial (capillary) blood concentration is the uni-directional flux of contrast molecules from the vascular space (capillaries) to the interstitial space provided that blood does not flow through arterial-venous shunts.
- Hepatic Arterial Fraction – HAF (Liver Tumor Protocol only) is expressed as a fraction between 0.0 and 1.0. It represents the liver blood input contributed by the hepatic artery as fraction of the total blood input. The Hepatic Artery and the Portal Vein need to be identified in the slice range.
- Time of Arrival – IRF T0 (Liver Tumor protocol only) is expressed in seconds and represents the time of arrival of the contrast agent at a given location, defined as the onset of enhancement (the first time point where the impulse residue function is not zero).

- Base Line Image – is an image created from the pre-enhancement range. It is an average of the data for these images and expressed in houndsfield units (HU).

The **CT Standard** Protocol provides the ability to create the following functional maps:

- Time to Peak – TTP is computed and displayed in seconds using the raw time curve data directly.
- Maximum Slope of Increase – MSI characterizes image maximum intensity change during dynamic process as slope of the time course values at each time course index. It is shown on the graph a blue line on the ROI curve.
- Maximum Slope of Decrease – MSD characterizes the minimum value of the slope and is shown as a red line on the ROI curve.
- Positive Enhancement Integral – PEI returns the integral over the image range of the difference between the value at each time point and the pre-enhancement value.

The **Import** Protocol provides the ability to redisplay functional maps in color without reprocessing.

DATA ACQUISITION METHOD FOR BRAIN STROKE PROTOCOL

1. Acquire an Axial non-enhanced series of the whole brain.
2. Review images and determine slice location at the level of the Basal Ganglia. This is slice just above the supra cellar cistern where the thalamus, basil ganglion, caudate nucleus can be seen. You must be sure there will be an artery and vein that can be detected within the slice range.
3. Inject 40cc of 370mgl/ml-strength contrast at 4cc per second using appropriate protocol listed below. For 300mgl/ml strength contrast, volume must be increased to 49/50ml and cine scan duration increased to 50 seconds.

Considerations:

- Additional location can be acquired with another injection of contrast after waiting for 5-10 minutes.
- If a CT Angiogram is to be included in the examination, it should be done before the CT Perfusion study. If an abnormality is seen in the CT Angio, define slice range to be consistent with findings.

LightSpeed/HiSpeed QX/i Protocol

Scan Type: Cine Full 1 sec.; Number of Images: 180, Thick/Speed: 5mm, 4i, 1 sec.; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 80; mA; 190-200; Total Exposure: 45sec; Prep Group: 5sec; Cine Duration 45sec.

Retro Recon data into 2i/10mm with 0.5 sec interval.

Or,

Scan Type: Cine Full 1 sec.; Number of Images: 360, Thick/Speed: 5mm, 4i, 0.5 sec.; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 80; mA; 190-200; Total Exposure: 45sec; Prep Group: 5sec; Cine Duration 45sec.

HiSpeed CT/i Protocol

Scan Type: Cine Full 1 sec; Number of Images: 45; Thick: 10mm; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 80; mA: 190-200; Matrix: 512; Total Exposure: 45sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec cine interval.

HiSpeed ZX/i/LX/i/FX/i/DX/i Protocol

Scan Type: Cine Full; Scan Time: 1 sec.; Number of Images: 45; Thick: 10mm; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 80; mA: 200; Matrix: 512 or 256; Total Exposure: 45sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

HiSpeed NX/i Protocol

Scan Type: Cine Full; Scan Time: 1 sec.; Number of Images: 90; Thick: 10mm; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 80; mA: 200; Matrix: 512 or 256; Total Exposure: 45sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

CT/e Protocol

Scan Type: Cine Full; Scan Time: 1 sec.; Number of Images: 45; Thick: 10mm; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 120; mA: 100-120; Matrix: 256; Total Exposure: 45sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

CT/e Dual Protocol

Scan Type: Cine Full; Scan Time: 1 sec.; Number of Images: 90; Thick: 10mm/2i; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 120; mA: 100-120; Matrix: 256; Total Exposure: 45sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

Non-CINE Protocol

If your scanner is not capable of a Cine acquisition, acquire axial dynamic data with 1-sec inter scan delay.

Scan Type: Axial, Scan Time: 1 sec.; Thick: 10mm; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 80; mA; 200; IDS: 1 sec; Matrix: 512 or 256; Total Exposure: 45sec; Prep Group: 5sec.

DATA ACQUISITION METHOD FOR BRAIN TUMOR PROTOCOL

1. Acquire an Axial non-enhanced series of the whole brain.
2. Review images and determine slice location at the level of the tumor. You must be sure there will be an artery and vein that can be detected within the slice range.

3. Inject 0.5ml of 300-370 mgl/ml-strength contrast per kilogram of body weight at 4cc per second using appropriate protocol listed below.

Considerations:

- Using a higher strength contrast and/or injection rates can improve results.
- Additional locations can be acquired with another injection of contrast after waiting for 5-10 minutes.
- Injection rate should be between 3-5 cc per second. As injection rate increase, cine scan duration can decrease. Conversely, as injection rate decrease, cine scan duration must increase to cover entire physiological cycle of blood flow in the brain.

LightSpeed/HiSpeed QX/i Protocol

Single Phase Data

Scan Type: Cine Full 1 sec.; Number of Images: 200; Thick/Speed: 5mm, 4i, 1 sec.; Interval: 0; Gantry Tilt: as needed; SFOV: Head, kV: 80; mA: 190-200; DFOV: 25, Total Exposure: 50sec; Prep Group: 5sec; Cine Duration 50sec.

Retro Recon data into 2i/10mm with 0.5 sec interval.

Or,

Scan Type: Cine Full 1 sec.; Number of Images: 200; Thick/Speed: 5mm, 4i, 1 sec.; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 80; mA: 190-200; DFOV: 25, Total Exposure: 50sec; Prep Group: 5sec; Cine Duration 50sec.

Dual-Phase Data

Group1: Scan Type: Cine Full 1 sec.; Number of Images: 200; Thick/Speed: 5mm, 4i, 1 sec.; Interval: 0; Gantry Tilt: as needed; SFOV: Head, kV: 80; mA: 190-200; DFOV: 25, Total Exposure: 50sec; Prep Group: 5sec; Cine Duration 50sec.

Group2: Scan Type: Axial 1 sec, Number of Images: 80, Thickness/Speed: 5mm, 4i, Interval: 0, Gantry Tilt: as needed, SFOV: Head, kV: 80, mA: 190-200, Total Exposure: 20 sec, Prep Group: 5 sec; IDS: 5sec; Total Elapsed Time: ~ 3min.

HiSpeed CT/i Protocol

Scan Type: Cine Full 1 sec; Number of Images: 50; Thick: 10mm; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 80; mA: 190-200; DFOV: 25; Matrix: 512 or 256; Total Exposure: 50sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

HiSpeed ZX/i/LX/i/FX/i/DX/i Protocol

Scan Type: Cine Full; Scan Time: 1 sec.; Number of Images: 50; Thick: 10mm; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 80; mA: 200; DFOV: 25,Total Exposure: 50sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

HiSpeed NX/i Protocol

Scan Type: Cine Full; Scan Time: 1 sec.; Number of Images: 100; Thick: 10mm/2i; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 120; mA: 100-120; Matrix: 512 or 256; Total Exposure: 45sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

CT/e Protocol

Scan Type: Cine Full; Scan Time: 1 sec.; Number of Images: 45; Thick: 10mm; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 120; mA: 100-120; Matrix: 256; Total Exposure: 45sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

CT/e Dual Protocol

Scan Type: Cine Full; Scan Time: 1 sec.; Number of Images: 90; Thick: 10mm/2i; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 120; mA: 100-120; Matrix: 256; Total Exposure: 45sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

Non-CINE Protocol

If your scanner is not capable of a Cine acquisition, acquire axial dynamic data with 1-sec inter scan delay so total elapse time from start of injection is 50-60 sec.

Scan Type: Axial, Scan Time: 1 sec.; Thick: 10mm; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 80; mA; 200; DFOV: 25, IDS: 1 sec; Matrix 512 or 256; Total Exposure: 50sec; Prep Group: 5sec.

DATA ACQUISITION METHOD FOR BODY TUMOR PROTOCOL

1. Acquire an Axial non-enhanced series through area of tumor.
2. Review images and determine slice location at the level of the tumor. You must be sure there will be an artery and vein that can be detected within the slice range.
3. Inject 0.5ml of 300-370 mgl/ml-strength contrast per kilogram of body weight at 4cc per second using appropriate protocol listed below.

Considerations:

- Using a higher strength contrast and/or injection rates can improve results.
- Use injection rates between 3 and 5 cc per second.
- Additional location can be acquired with another injection of contrast after waiting for 5-10 minutes.
- If the patient cannot hold their breath for the duration of the scan, have the patient breathe very shallowly and slowly to minimize organ movement. Placing a restraint strap tightly around the patient may help to minimize breathing motion along with slow shallow breathing.

- For prostate exam, compression and having the patient hold very still should be adequate to acquire images without motion of that anatomical area.

LightSpeed/HiSpeed QX/i Protocol

Scan Type: Cine Full 1 sec.; Number of Images: 200; Thick/Speed: 5mm, 4i, 1 sec.; Interval: 0; Gantry Tilt: as needed; SFOV: Large; kV: 120; mA: 60; DFOV: as needed, Total Exposure: 50sec; Prep Group: 5sec; Cine Duration 50sec.

Retro Recon data into 2i/10mm with 0.5 sec interval.

HiSpeed CT/i Protocol

Scan Type: Cine Full 1 sec; Number of Images: 50; Thick: 10mm; Interval: 0; Gantry Tilt: as needed; SFOV: Large; kV: 120; mA: 60; DFOV: as needed; Matrix: 512 or 256; Total Exposure: 50sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

HiSpeed ZX/i/LX/i/FX/i/DX/i Protocol

Scan Type: Cine Full; Scan Time: 1 sec.; Number of Images: 50; Thick: 10mm; Interval: 0; Gantry Tilt: as needed; SFOV: Large; kV: 120; mA: 60; DFOV: as needed; Matrix: 512 or 256, Total Exposure: 50sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

HiSpeed NX/i Protocol

Scan Type: Cine Full; Scan Time: 1 sec.; Number of Images: 45; Thick: 10mm/2i; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 120; mA: 60; Matrix: 512 or 256; Total Exposure: 45sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

CT/e Protocol

Scan Type: Cine Full; Scan Time: 1 sec.; Number of Images: 45; Thick: 10mm; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 120; mA: 60; Matrix: 256; Total Exposure: 45sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

CT/e Dual Protocol

Scan Type: Cine Full; Scan Time: 1 sec.; Number of Images: 45; Thick: 10mm/2i; Interval: 0; Gantry Tilt: as needed; SFOV: Head; kV: 120; mA: 60; Matrix: 256; Total Exposure: 45sec; Prep Group: 5sec.

Retro Recon data with 0.5 sec interval.

Non-Cine Protocol

If your scanner is not capable of a Cine acquisition, acquire axial dynamic data with 1-sec inter scan delay so total elapse time from start of injection is 50-60 sec.

Scan Type: Axial, Scan Time: 1 sec.; Thick: 10mm; Interval: 0; Gantry Tilt: as needed; SFOV: Large; kV: 120; mA: 60; DFOV: as needed, IDS: 1 sec; Matrix 512 or 256; Total Exposure: 50sec; Prep Group: 5sec.

GETTING STARTED WITH CT PERFUSION 3 SOFTWARE

1. From the **[Browser]** on a AW 3.1 system or the **[Patient List]** on a AW 4.0 or AW4.1 system:
   - Select CT Perfusion series for the desired patient.
2. Select **(CT Perfusion 3)** from the list of software applications available:
   - The CT Perfusion 3 user interface will be displayed.
   - If CT Perfusion 3 is already running, click on **(New Protocol)** and select a new series to load.
3. Select a protocol from the available icons:
   - **(CT Standard)** – Provides capability to create functional map using Time to Peak, Maximum Slope of Increase, Maximum Slope of Decrease, Positive Enhancement Integral algorithms.
   - **(Brain Stroke)** – Provides protocol for computation of functional maps for brain disturbance - “stroke”.
   - (**Brain Stroke-Automatic)** – Provides automatic computation of functional maps for stroke.
   - **(Brain Tumor)** – Provides protocol for computation of functional maps for brain tumor.
   - **(Body Tumor)** – Provides protocol for computation of functional maps for body tumor.
   - **(Import Image)** – Provides ability to redisplay functional map(s) in color in CT Perfusion 2.
   - Click on a protocol icon and the CT Perfusion 3 guidance panel will open over the lower left viewport.
   - Select **(Help)** to open a help screen for more information for the current step.
   - Select **(Close)** to exit the guidance panel, or click on the **Title Bar** of the guidance panel and move the panel to another viewport and leave the panel open. If you close the panel, click on the **[Protocol Name]** in the CT Perfusion 3 main control panel to reopen the guidance panel.

CREATING FUNCTIONAL MAPS WITH CT PERFUSION 3 SOFTWARE

STEP 1: IMAGE REGISTRATION

- Image Registration is an optional process to apply a 2D image registration to minimize patient motion effects in the x or y plane that might have occurred during the acquisition of the time course data for the perfusion acquisition.
- Image Registration takes about 0.6sec per image to register the images.
- Image Registration is available for Brain Stroke and Brain Tumor protocols only.
- Select **(Apply Registration)** to perform the 2D image registration. Image registration can be performed again if there is residual motion visible after review of images. Click on image number for **Rank** with middle mouse to scroll through images for displayed location. Default **Settings** values are: **Low Threshold** of 1000, **High Threshold** of 1500 and **Number of Control Points** of 1000.
- Select **(Stop)** in the CT Perfusion 3 main control panel to cancel an image registration that is in progress.
- Select **(Next)** to proceed to the next step.

STEP 2: PROCESSING THRESHOLDS

- Set thresholds to eliminate noise and exclude CT numbers outside a specified range from processing on the ***first*** image of the series:
  - **Air** threshold defines the lower threshold HU value.
  - **Bone** threshold defines the upper threshold HU value.
  - Radial buttons reset entries back to default values. Right button resets **Bone** threshold to default value of 120 and left button resets **Air** threshold to default value of 0 in case of Brain Stroke protocol.
- System sets the threshold to a default value.
- The display is either shaded or not shaded based on thresholds set: Set threshold so that bone is white and will be excluded from the reconstruction. The area shaded with diagonal green lines will be included in the processing of the functional maps. Be careful to make sure you do not exclude area of enhancement of a tumor that may be significantly dense when setting the bone threshold. Use the ***first*** image of the series to set the threshold ranges.
- Click on the **Left Slider** and move to set Air or low Threshold, or use the **<Right Arrow>** or **<Left Arrow>** to decrement or increment the lower threshold.
- Click on the **Right Slider** and move to set Bone or high Threshold, or **<Shift-Right Arrow>** or **<Shift-Left Arrow>** to decrement or increment the upper threshold.
- Use radial **(Reset)** buttons to return values back to defaults.

- Select **(Next)** to proceed to the next step.

STEP 3: ARTERY INPUT

- Review the images using **Rank** (middle mouse click with cursor over image number; and move right to increase number or move left to decrease number, or click right to increase and left to decrease number).

  Or,

- Use the **(Review Controller)** button, in the CT Perfusion 3 main control panel, to display the Review Controller for review of the images. The **(Show/Hide Review Controller)** button is to the left of the **(Show Functional Data)** button. Review Controller allows the user to play a cine loop, manually review the images at each location. The Review Controller opens automatically when your mouse is positioned over the series view in the top left viewport. Select the **[X]** in the corner of the Review Controller to hide the review tool.
- For Brain Stroke, Brain Tumor and Soft Tissue tumor protocols identify an image where an artery is seen to define the arterial input vessel and another image where a vein is seen to define the venous input vessel. For Body Tumor, Kidney, Prostate, Pancreas, Spleen and Bone, identify image where artery is to define the arterial input vessel. For the Liver Tumor protocol, an artery and the portal vein must be visualized in the imaging volume to be defined as the input vessels.
- Place a small ROI in the vessel to be used as the artery input.
- Time Intensity Curve for the ROI will be displayed on the Graph View with the ROI number and slice location annotation. The Time Intensity Curve for the ROI can be scaled to fit the Graph View by pressing on the **<Space Bar>**. An active (green) ROI will be scaled to fit the graph over an inactive (purple) ROI. If all ROIs are inactive they will be scaled to fit within the Graph View.
- Select **(Next)** to proceed to the next step.

Tips on vessel selection:

Several points within a vessel as well as other vessels with in the slice location should be compared to find:

1. Vessel and area within vessel of highest intensity.
2. Vessel with fastest rising slope. Use **[Set Y Unit]>(Shape Comparison)** mode of the Graph View on-view menu (or, select **(Shape Comp.)** in **[Pref./Settings]>[Graph View]>Graph Preferences** panel), to compare several ROIs. Shape Comparison mode sets all the graphs to a same nominal base line so ROIs can be more easily compared.
3. Use small ROIs of 4-10 pixels in size.
4. Artery and vein do not have to be defined on the same image.
5. Artery and vein do not have to be on the same slice location. If a vein and artery are selected on different slice locations, the graph view will display both traces with the slice location is displayed beside the ROI number in parentheses.
6. Magnify the images using **DFOV** value displayed on the image to make manual placement and sizing for small ROIs easier.

7. Using the **(Unsmooth)** mode, in the CT Perfusion 3 main control panel, to review vessel intensity may help make selection of the highest intensity portion of the vessel easier.
8. Small manually defined ROIs may be difficult to move unless the image is magnified.
9. Automatically defined ROIs cannot be moved; but they can be deleted.
10. Using **(Create Freehand ROI)** or **(Create Pixel List ROI)** mode may be the easiest method to manually draw an irregular ROI.

Defining a ROI:

- **(Manual)**, **(Automatic)** and **semi-Automatic** (constrained) modes are available.
- **Automatic** mode will automatically define an artery and label the selection. In **semi-Automatic** or constrained mode, a ROI can be used to define the area where the system should automatically search within for an artery.
- To use the **Automatic** mode with unconstrained search for artery input, select **(Next)** to proceed to the next step. The system will search the entire image set for the best arterial input vessel and place an ROI within it and label it as ***Artery***. **Automatic** mode does not work well for vessel selection for Body Tumor protocol. Use **Manual** or **semi-Automatic** modes for Body Tumor protocol.
- To use **semi-Automatic** or constrained mode, place an active (green) ROI in the area you want the system to search for an artery and select **(Next)**. The system will delete the search ROI after it detects and labels an artery found within the region defined by the search ROI.
- **Manual** mode allows user to select the artery by defining a ROI in it. This mode does not automatically label the selected vessel.
- For **Manual** mode, first review the images, select slice were an artery is well visualized, and place a small ROI in it, select **(Manual)** and then **(Next)**.
- When using **Manual** mode, the active ROI (green) will be used to define the Arterial input vessel when **(Next)** is selected.
  - Select **(Create Box ROI)** or **(Create Ellipse ROI)** from the CT Perfusion 3 main control panel to define the region of interest within the vessel.
  - To define an irregular ROI, hold the **<Shift>** key down and click left directly on the view. The cursor will turn into a pencil and then use the mouse to draw the ROI.
  - To define a freehand ROI, select **(Create Freehand ROI)** or **(Create Pixel List ROI)** mode from the CT Perfusion 3 main control panel. The cursor will turn into a pencil and then use the left mouse to define the pixels for the ROI.
- Select **(Next)** to proceed to the next step.

STEP 4: VEIN FOR PARTIAL VOLUMING CORRECTION OR PORTAL VEIN INPUT

(BRAIN STROKE, BRAIN TUMOR, LIVER TUMOR, SOFT TISSUE ONLY)

- Review the images using **Rank** (middle mouse click with cursor over image number; and move right to increase number or move left to decrease number, or click right to increase and left to decrease number).

  Or,

- Use the **(Review Controller)** button, in the CT Perfusion 3 main control panel, to display the Review Controller for review of the images. The **(Show/Hide Review Controller)** button is to the left of the **(Show Functional Data)** button. Review Controller allows the user to play a cine loop, manually review the images at each location. The Review Controller opens automatically when your mouse is positioned over the series view in the top left viewport. Select the **[X]** in the corner of the Review Controller to hide the review tool.
- For Brain Stroke, Brain Tumor or Soft Tissue tumor protocol, identify an image where a vein is seen to define the venous output vessel. For the Liver Tumor protocol, identify image where the portal vein is visualized to define the venous output vessel.
- Place a small ROI in the vessel to be used as the Vein for Partial Volume Correction input or for the Portal Vein Input.

Defining a ROI:

- **(Manual)**, **(Automatic)** and **semi-Automatic** (constrained) modes are available.
- **Automatic** mode will automatically define a vein and label the selection.
- In **semi-Automatic** or constrained search mode, a ROI can be used to define the area where the system should automatically search within for a vein.
- The vein is used to normalize the arterial input because: (a) the arterial enhancement curve is underestimated because of partial volume averaging while the vein is not; (b) to correct for the underestimation of the arterial curve, it is multiplied by the ratio of the area underneath the vein curve to the area underneath the arterial curve.
- To use the **Automatic** or unconstrained search mode for artery input, select **(Next)** to proceed to the next step. The system will search the entire image set for the best venous output vessel and place an ROI within it and label it as ***Vein***. **Automatic** mode does not work well in for vessel selection for Body Tumor protocols. Use **Manual** or **semi-Automatic** modes for Body Tumor protocols.
- To use **semi-Automatic** or constrained search mode, place an active (green) ROI in the area you want the system to search within for an artery and select **(Next)**. The system will delete the search ROI after it detects and labels a vein found in the region defined by the search ROI.
- **Manual** mode allows user to select the vein by defining a ROI in it.
- For **Manual** mode, first review the images, select slice were a vein is well visualized, and place a small ROI in it, select **(Manual)** and the **(Next).**
- When using **Manual** mode, the active ROI (green) will be used to define the venous input vessel when **(Next)** is selected.
  - Select **(Create Box ROI)** or **(Create Ellipse ROI)** from the CT Perfusion 3 main control panel to define the region of interest within the vessel.
  - To define an irregular ROI, hold the **<Shift>** key down and click left directly on the view. The cursor will turn into a pencil and then use the mouse to draw the ROI.
  - To define a freehand ROI, select **(Create Freehand ROI)** or **(Create Pixel List ROI)** mode from the CT Perfusion 3 main control panel. The cursor will turn into a pencil and then use the left mouse to define the pixels for the ROI.
- The Time Intensity Curve for the ROI will be displayed in the Graph View with the ROI number and slice location where defined. The Time Intensity Curve can be scaled to fit the Graph View by pressing on the **<Space Bar>.**

- Select **(Next)** to proceed to the next step.

STEP 5: PRE / POST - ENHANCEMENT IMAGES

Make sure that both time intensity curves displayed in the **Graph View** are purple (inactive). Move the cursor to the **Graph View** and press the **<Space Bar>** to scale the plots to fill the graph viewport.

Last pre-enhancement image:

- For all protocols, **Last pre-enhancement image** is defined as the last image prior to the arrival of contrast using the Artery ROI time density curve in the Graph View. This provides a baseline. You must have at least one image prior to the arrival of contrast.
- The system will automatically define the image for **Last pre-enhancement image**. Review this selection and modify if needed.

Or,

- Use the slider to select the image on the artery ROI time density curve in the Graph View that is last image prior to the arrival of contrast. As you move the slider, the cursor line will track on the graph.

First/Last post-enhancement image:

- For Brain Stroke protocol, **First post-enhancement image** is defined as the point where re-circulation begins or point after the first pass of the bolus through the brain using the time density curve from an ROI in the affected (abnormal) region of the brain in the Graph View. In the case that there is no obvious abnormal region, then choose a MCA region in either the right or left hemisphere.
- For a single phase Brain Tumor, Body Tumor, Liver Tumor, Kidney, Prostate, Pancreas, Soft Tissue, Spleen, or Bone protocols, **First post-enhancement image** is defined as the last enhanced image in the series. If the last image is not selected, the Permeability Map will not be calculated correctly.
- In dual phase data for Brain Tumor, Body Tumor, Liver Tumor, Kidney, Prostate, Pancreas, Soft Tissue, Spleen, or Bone protocols, **First post-enhancement image** is defined as the last enhanced image in the first (phase) cine group. The **Last second phase image** is defined as the last image in the second phase of the dual phase data.
- Using the slider, select the image on the Artery ROI time density curve where re-circulation of contrast begins for brain stroke protocols. For tumor exams, select the last image of the cine portion of the acquisition. As you move the slider, the cursor line will track on the graph.
- Select **(Next)** to proceed to the next step.

STEP 6: FINAL SETTINGS

- **Final Settings** panel displays a table of the inputs defined in each step in the guidance panel for the selected protocol.

  Artery, Vein, Last pre-enhancement, First post-enhancement, Last second phase, Threshold (Air and Bone) values are displayed in the table.

  Use **(Film/Save)** to film the Final Settings page, to save it as a screensave image, to save it as a TIFF image to hard disk, or to save it as a TIFF image to floppy. Filming or saving a copy of the Final Settings page is useful to review settings that were used or for recreation of the maps from the original data at a later date.

- Use the **(Advanced Settings)** button to define advanced parameters for **Display**, **Blood Flow**, **Hematocrit** and **Tissue**. The settings in **[Physiology]** for **Blood Flow**, **Hematocrit** and **Tissue** do not need to be adjusted unless you are conducting a specific investigation. The settings in **[Time]** for **Temporal Smoothing**, **Temporal Sampling (first phase and second phase)** are used for dual phase data to change temporal sampling.
- In **[Display]**, check settings for:
  - **Algorithm Resolution** defines the number of pixels that will be used to compute the functional image maps. Default value is 3; which means every third pixel will be used in computation of the functional image map(s). The lower the number the higher the resolution but with an impact on compute time.

    Select a radial button or explicitly enter a value in **Custom** type-in field to set **Algorithm Resolution** for the image. Range is 1 to 16.
  - **Spatial Smoothing** – defines strength of spatial smoothing function. Default is 5. 1 is no spatial smoothing and 10 is a 10x10 pixels spatial smoothing factor applied to the functional map(s).

    Use the slider to set **Spatial Smoothing** for the functional maps. Range is 1 to 10.
  - Select **(Done)** when you are satisfied with the Advanced Settings. Select **(Save)** and then **(Done)**, if you want to permanently change the values for algorithm resolution and spatial smoothing. Select **(Reset)** to return to original values before selecting **(Done)**.
- Select **(Compute)** to compute the functional image maps. The system will create a set of functional maps for the slice location currently displayed. Create maps for each slice location by changing the slice location displayed or using Functional Maps Film/Save option.
- Select **(Close)** to close the guidance panel.
- Select **[Protocol Name]** in the CT Perfusion 3 main control panel to reopen the guidance panel. Click on the **{Parameter Name}** to return to the guidance panel for that step to modify input values and then re-compute the functional maps.

  Or, select **(New Protocol)** and redefine a completely new set of input values.

STEP 7: FUNCTIONAL VIEW CONFIGURATION

The two lower viewports will have functional maps displayed in them after a computation has been done. Otherwise, the viewport may display the message "**No functional image available**".

Click on the **[Functional Map Name]** active annotation in either viewport to display pull-down menu with a list of the functional maps created. Select another functional map name to display a different map in the viewport.

- The functional maps are automatically displayed with the following set of default color ramps:

  Blood Volume – Rainbow;

  Blood Flow – 3 Colors;

  Mean Transit Time – Inverse Rainbow;

  Permeability Surface – Rainbow;

  Hepatic Arterial Fraction – Rainbow.

  Color ramp for the functional maps can be changed by using on-view selection (click right with the mouse – select **[Color Ramps]**, then select another color ramp). **(Puh Thallium)** could be another

color ramp selection for Blood Volume and Blood Flow functional maps. Use the **(Gray Levels)** color ramp to save functional maps to be networked to a PACS system that is not compatible with color.

Default color ramp and **Min** / **Max** ranges for the Functional Maps can be defined in **[Pref./Settings]>[Display]**. Select **(Next)** in the **Display Preferences** panel. Select the **Functional Map** (the map needs to be displayed in one of the viewports); select the **Color Ramp** to be used for the selected **Functional Map**. To change the scale for a currently displayed map, enter desired value in **Min** and **Max** type-in fields. Select **(Save)** to save changes as default display presentation. **(Reset)** will set the values back to GE default settings. Click **(OK)** in pop-up for confirmation of save for display preferences to continue.

- Use the **[Split View]** / **[Enlarge View]** options from the on-view menu to display four maps or a single map in a functional viewport.

  Or, enter a backslash **< / >** in a viewport to toggle between multiple and single functional map(s) display. When switching between 4 to 1 maps per viewport, the system will display the map where the cursor is positioned as the single view.

- Viewports are synchronized (locked/linked together) to change images displayed in the viewports based on slice location selected. The functional viewports can be unsynchronized (unlocked/unlinked) to allow up to 8 different maps from different locations to be displayed at one time. Select **[Pref./Settings]>[Display]**, remove the check mark for **Synchronize Locations**, and then select **(Close)**. The annotation **(locked)** will be displayed beside the slice location annotation in the viewport. Click on **(locked)** and to change it to **(unlocked)**. In **(unlocked)** viewports, the slice location can be changed independently from other viewports, which are in the **(locked)** state.

- The color scale displayed at the side of each of the functional maps defines the low and high quantitative range for the map and how the color scale is distributed. Change the upper limit value to change the window level of map instead of using the mouse as you would normally window and level an image.

STEP 8: CLOSING CT PERFUSION 3

- When review, filming and saving of functional maps, series view and graph view is complete, select **(Close)** in the CT Perfusion 3 main control panel to exit CT Perfusion 3 and return to the Browser / Patient List.

CREATING SYMMETRICAL ROI GROUPS WITH CT PERFUSION 3

1. Click on **(Create Symmetry Axis)** icon in the CT Perfusion 3 main control panel. A line will be displayed on the series view. Place the line so it aligns with the mid line of the brain or anatomical structure of interest. Move the annotation box to one end of the line and enter **Axis**.
2. Place ROIs in one hemisphere of the brain or anatomical structure of interest.
3. Once all the ROIs have been deposited, hold the **<Control>** key and select all the ROIs you want to duplicate to the other half of the image and select the axis line.
4. Click on **(Create Symmetrical ROIs)** icon in the CT Perfusion 3 main control panel. The system will automatically duplicate all the ROIs selected to the other half of the image.

PREFERENCES SETTINGS WITH CT PERFUSION 3

Click on **[Pref./Settings]** in the CT Perfusion 3 main control panel. Selection menu will be displayed.

- **[Graph View]** – Sets preferences for the Graph View. Define vertical (Y) and horizontal (X) units and **ROI List Preferences**. The value for **Cursor** sets the default size of the cursor when CT Perfusion 3 initially opens. Select **(Next)** to define the **ROI List Preferences**.
- **[Saving]** – Defines how the images will be saved when **(Save)** is used in **[Film/Save]>[Functional Maps]** or in **[Film/Save]>[Series Data]** and to set **Save SCREENSAVE images in colors** "**On**" or "**Off**". By default, Series data save type is set to REFORMAT and Functional maps save type is set to PROCESS.
- **[Regions of Interest]** – Allows user to define the statistics to be shown in the series view, the functional views or in the ROI statistical panel for prescribed ROIs. The ROI statistical values can be shown for **Area**, **Average**, **Percentage from selected ROI**, **Min**, **Max**, **Standard Deviation** and **Relative Deviation**. Select **(Next)** to display panel where values to be displayed in the ROI statistical panel can be defined.
- **[Display]** – Defines display of **Patient Name** "**On**" or "**Off**", display of **Annotations** "**On**" or "**Off**", **Grid Size** and automatic display of **Grid** "**On**" or "**Off**", **Synchronization** of the viewports "**On**" or "**Off**", and the **Functional** (Maps) **Display Preferences** for color ramp and min/max values. Select **(Next)** to define the **Functional** (Maps) **Display Preferences**.

FILMING AND SAVING FUNCTIONAL MAPS AND ROI TEMPLATES

Click on **[Film/Save]** in the CT Perfusion 3 main control panel. Selection menu will be displayed.

- **[Filmer] / [Scrapbook] / [Film Composer]** – Displays the Film Composer for AW 3.1, Scrapbook for AW4.0 or Filmer for AW4.1.
- **[Series Data]** – Saves or films the currently displayed image for the time course data. By default, the **Save as a SCREENSAVE image** option is selected. You can save as a TIFF file to floppy disk using **<Control-T>** key or selecting **Save as TIFF** on **Floppy Disk** in the panel.
- **[Graph Data]** – Saves or films the currently displayed graph(s). The graph can be saved in a temporal data, histogram or ROI value format. By default, the **Save as a SCREENSAVE image** option is selected. There is option to save as a TIFF image or TEXT file to floppy disk using **<Control-T>** key and **<Control-G>** key respectively or selecting **Save as TIFF** on **Floppy Disk** or **Save as TEXT** on **Floppy Disk** in the panel.
- **[Functional Data]** – Defines format for saving functional statistical data in a table format. The following formats are available:
  - **Send to Filmer / Send to Scrapbook / Send to Film Composer** films the functional statistical data panel.
  - **Save as SCREENSAVE image** saves the information shown in the functional statistical data panel as a Screen Save image.
  - **Save as TEXT** on **Hard Disk** / **Floppy Disk** saves the information shown in the functional statistical data panel as a TEXT file to either hard disk or floppy disk.
  - **Save as TIFF** on **Hard Disk** / **Floppy Disk** saves the functional statistical data panel as to TIFF image to either hard disk or floppy disk.

- **[Functional Maps]** – There are several options: Saving functional maps based on their visibility using **Visible Maps** / **Left, Right** or **All** / **Select from available maps** to define which of the maps you want to save; and how many locations the maps should be saved for using **Single Location** or **Multiple Locations**.

Select the functional map(s) to be saved:

- **Visible** allows the user to select which viewport the image will be saved from.
- **All** allows the user to save all displayed functional maps.
- **Select from available maps** allows the user to select which of the functional maps they want to be saved from a list (Blood Volume, Blood Flow, Mean Transit Time, Permeability Surface…).
- **Single Location / Multiple Locations** allows the user to select maps to be saved for a single location or for all (Multiple) locations loaded into CT Perfusion 3.

Define the format for saving among the following formats:

- **Send to Filmer / Send to Scrapbook / Send to Film Composer** films the functional maps. Or, place cursor over a viewport and press the **<F1>** key.
- **Save as SCREENSAVE image** to save viewport with cursor over it as an image (annotations and ROIs will be saved but not editable any longer) or place cursor over viewport and press **<S>** key to save as Screen Save to hard disk.
- **Save as processed image** to save image in PROCESS/REFORMAT/SCPT format. PROCESS or REFORMAT formats are required if you want to re-open the maps in CT Perfusion 3 using **Import Image** protocol or place cursor over viewport and press the **<F>** key to save map to hard disk.
- To save image as a TIFF file on hard disk / floppy disk, select respectively **Save as TIFF** on **Hard Disk** / **Floppy Disk** or position cursor over a view and press **<T>** / **<Control-T>** key.

Select **(Save)** to save images of the selected viewports or to send these images to the Film Composer (AW 3.1) / Scrapbook (AW 4.0) / Filmer (AW4.1) based on the selection in the guidance panel.

- **[ROIs/Templates]** – Allows user to select a ROI template to be displayed on the Series and Functional Views from a list of saved templates, create a ROI template and save it, or save ROIs as part of the exam. ROI templates saved as part of the exam can be archived to CD or MOD or networked. They can be selected and displayed in CT Perfusion 3 as part of the exam to recreate the exact ROI placement.
  - **New Template** allows user to create a new set of ROIs as a template and save it for future use. Define a set of ROIs (all ROIs to be saved in the template must be active –green), select **New Template** – a type-in field is available; enter the name for the template, select **(Save)**. The new template will be displayed in the Template ROI list.
  - **Save to / Load from Exam** allows the user to save a set of ROIs as part of the patient exam or display a set of ROIs previously saved as part of the patient exam. Define ROIs, select **Save to / Load from Exam**, a type-in field is opened; enter the name for the template, select **(Save)**. The ROIs will be saved as series in the current patient's exam. To display a set of saved ROIs, select **Save to / Load from Exam**, toggle to **Browser** / **Patient List**, select ROIs series, select **(CT Perfusion 3)**, select **(Load)**. The saved ROIs will be displayed on the series and functional views.

FILMING AND SAVING FUNCTIONAL DATA

Click on **[Film/Save]** in the CT Perfusion 3 main control panel. Select **[Functional Data]**.

- Display the Functional Statistical information panel by selecting **(Show Functional Data)** button in the CT Perfusion 3 main control panel. The Functional Statistical information panel will be displayed. The patient name, date of exam and exam number is displayed at the top of the panel. Currently displayed ROIs will be shown in the panel with statistical information for maps and ROI values defined in the **[Pref./Settings]>[Regions of Interest]**.
- Select format to save or film the information, then select **(Save)**. The system will film or save all the pages for the available functional data. Saving the functional statistical data as a screensave makes the information part of the exam for easy review of the ROI statistical data.

  The following options are available for filming or saving Functional Data:

  - **Send to Filmer / Send to Scrapbook / Send to Film Composer** films functional data. If there is more than one page of functional data, each additional page will also be filmed.
  - **Save as SCREENSAVE image** to save functional data. If there is more than one page of functional data, each additional page will be saved as separate Screen Save image.
  - **Save as TEXT** on **Hard Disk** / **Floppy Disk** to save functional data as a TEXT file on hard disk / floppy disk.
  - **Save as TIFF** on **Hard Disk** / **Floppy Disk** to save functional data as a TIFF image on hard disk / floppy disk.

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