CT Brain Shuttle Perfusion
CT Brain Shuttle Perfusion: Overview

- The CT Brain Shuttle Perfusion workflow is for assessing perfusion disturbances within the brain using thin-slice, wide-volume data.

- Vitrea® software identifies the artery and vein, then computes five color-coded image maps with quantitative results related to the patient’s regional cerebral blood volume (rCBV), mean, transit time (MTT), regional cerebral blood flow (rCBF), time to peak of tissue (TTP), and delay of tissue response (Delay).

- Perfusion studies with shuttle are scanned in a variety of subsets with wide-coverage acquisition protocols. Vitrea software builds volumes from data from supported thin-slice scanners and scanning protocols including jog and helical acquisition.

- Vitrea software interpolates between time points so that the full range is viewable within the volume. Volumes will have “interpolated” labeled in view.

- Vitrea software uses the input artery with the earliest transit time and the output vein with the maximum total density to calculate brain perfusion.
# CT Brain Shuttle Perfusion: Perfusion Maps

<table>
<thead>
<tr>
<th>Identification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rCBV (regional Cerebral Blood Volume)</td>
<td>The distribution of blood per unit brain tissue. It provides evaluation of autoregulation (collateralization).</td>
</tr>
<tr>
<td>rCBF (regional Cerebral Blood Flow)</td>
<td>The blood volume running throughout the capillary blood vessels per unit time per unit brain tissue. CBF identifies areas of low blood flow.</td>
</tr>
<tr>
<td>MTT (Mean Transit Time)</td>
<td>The average amount of time that blood takes to transit through the capillary vessels. Increases in MTT indicate vasodilatory response to reduced flow.</td>
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<tr>
<td>TTP (Time to Peak of tissue response curve)</td>
<td>Demonstrates the relative time of peak enhancement for brain tissue voxels. It provides an indication of delayed flow due to stenosis or occlusion and is useful for identifying collateralization.</td>
</tr>
<tr>
<td>Delay (Delay time of tissue response curve)</td>
<td>Demonstrates the relative arrival time of contrast medium for tissue voxels. The information the delay map provides is similar to TTP although the calculation method differs. (The delay time is used to correct the MTT values.)</td>
</tr>
</tbody>
</table>

**NOTE:** In the case of arterial occlusion, brain tissue survives if sufficient collateral flow is present. In essence, it does not matter when the oxygenated blood arrives in the brain, as long as it arrives in the appropriate concentration. A delay in blood flow can therefore be ignored for perfusion.
CT Brain Shuttle Perfusion:

The Steps:
• Open Vitrea® software and select patient.
• Load CT Brain Perfusion (Jog or Shuttle) thin-Slice dataset.
• Review the Time-Density graph.
• Review the artery and vein position.
• If necessary, edit the artery and/or vein position.
• Display Perfusion Maps.
• Set the Window/Level values.
• Edit the Brain Mid-Line.
• Use ROI Templates.
• Display Summary Map.
• Take Snapshot.
• Create Batch Collage.
• Export Results.
CT Brain Shuttle Perfusion- Select Study

Launch Vitrea®

**Left** mouse click to select the patient.

Select the **Applications** tab. Double click **Brain Shuttle Perfusion Applications**.

Launching from the Applications Tab places you directly into the Advanced Viewer.
Click the Series Tab.

Hold down `ctrl` and select the series.

Click on Advanced Viewer to launch the application.

This approach to loading the study will take you to the Gallery page of the Advanced Viewer first.
Select **Brain Perfusion CT** from the Protocol List.

Click **Pick** next to **Shuttle Perfusion**.

Tip- If non-shuttle/jog data is loaded, Shuttle Perfusion will *not* be an option.
Review the Time-Density curve to visualize proper artery/vein location.

The Time-Density graph displays the density over time curve and the transit time for the artery in red, and displays the density over time curve, area under the curve, and transit time for the vein in blue.
CT Brain Shuttle Perfusion: Review Time-Density Graph

Time-Density Graph (Artery and Vein Locations)

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Range of density</td>
<td>The difference between the peak and baseline of either the artery or the vein, whichever difference is greater</td>
</tr>
<tr>
<td>2</td>
<td>Transit time for the artery location</td>
<td>Mean time for the first pass of contrast to reach the artery location</td>
</tr>
</tbody>
</table>
**CT Brain Shuttle Perfusion: Review Time-Density Graph**

Time-Density Graph with the crosshair in the brain perfusion image will generate additional information.

Review the Time-Density graph and ensure:

- The rise in the curves start after time 0.
- The curves do not have multiple peaks.
- The artery curve peaks before the vein curve. Some time of washout is present.

**If either the red or blue curves look inappropriate, override the artery or vein location. Incorrect vessel locations result in invalid perfusion maps.**
CT Brain Shuttle Perfusion: Locate Artery and Vein Position

Click the Red line to locate the Artery position (red dot).

Click the Blue line to locate the Vein position (blue dot).
CT Brain Shuttle Perfusion: Edit Artery and Vein Position

Right-click and drag left and right to scroll temporally and drag forward and back to scroll spatially to locate the earliest enhancing artery. (typically the internal carotid or a cerebral artery).

Tip: Avoid including coils or aneurysm clips in the ROI. Edit contour as needed.
CT Brain Shuttle Perfusion: Edit Artery and Vein Position

You must be in the Orthogonal MPR to draw an ROI. Click the MPR mode to switch between the two modes. Draw the ROI.

Click the Perfusion Analysis menu to expand options.

Select Artery to locate a new Artery position.

Select Compute.

Repeat to locate and change the vein position.
CT Brain Shuttle Perfusion: Display the Perfusion Maps

- Select the **Axial** Brain Perfusion Maps screen format.

- Select the **MPR** Brain Perfusion Maps screen format.

- Select the **VR** Brain Perfusion Maps screen format.
CT Brain Shuttle Perfusion: Window/Level Perfusion Maps

Click the W/L menu in the lower right corner of a perfusion map. Select from the options.

- **Apply Fixed W/L** - a fixed setting for the map
- **Apply Fixed W/L (All)** - applies the fixed setting to all the maps
- **Apply Auto W/L (default setting)** – Vitrea assesses the map and computes a setting based on scan-specific factors using ASIST guidelines.
- **Apply Auto W/L (All)** - applies the auto setting to all the maps.
- **Apply ROI W/L** - Vitrea assesses the ROI and normalizes the map to the region.
- **Apply ROI W/L (All)** - applies the ROI setting to all the maps.
CT Brain Shuttle Perfusion: Edit Brain Midline

Select Brain Midline in the View Options Menu.

Make required edits to adjust the brain midline.

TIP: Edit in the coronal view first, then in the axial view.
Select Auto-Oblique.

Displays an Oblique MPR view along the mid-axis.
CT Brain Shuttle Perfusion: ROI Templates

Select the ROI Template menu from the drop-down. Choose the ROI Template style.

ROI Templates are placed equidistant to the Brain Midline.
CT Brain Shuttle Perfusion: ROI Templates

- **Right click** and select **ROI**.

- **Hover** the pen over the center of any ROI to reposition it. **Edit** any contour to correct ROI shape. **Auto Mirror** will apply the change to the identical ROI on the opposite side.
CT Brain Shuttle Perfusion: Manual ROI

Click on **Ellipse**.

Under **View Options**, check **Brain Midline** and **Auto Mirror**.

This will mirror the **ROI** that is placed on the contralateral side.

**Draw** a **ROI** on the image.
CT Brain Shuttle Perfusion: Summary Maps

The Brain Perfusion Summary Map displays color-coded regions based on a derivative of the hemispherical comparisons of all the other maps, where perfusion values appear to be increased or decreased based on the contralateral hemisphere.

- The Summary Map image can be used to communicate the results of a CT Perfusion exam and to provide tissue classification.

- For areas marked as Yellow, Vitrea software uses a relative value where TTP is increased, in seconds, compared to the reference hemisphere.

- For areas marked as Red, Vitrea software uses a relative value where CBV is decreased, in percent, compared to the reference hemisphere.

- The Summary Map is a simplified derivative of the other perfusion maps. The software compares the two hemispheres to make distinctions of “maintained,” “reduced,” and “increased.”
CT Brain Shuttle Perfusion: Summary Maps

The numbers that display in the tool tip when you adjust the slider bars are based on the software-generated distinctions. If the top slider shows a TTP value of +5 seconds, that means that TTP values that are more than 5 seconds greater than the average TTP within the contralateral MCA territory are considered “increased.”

Similarly, if the bottom slider shows a CBV value of -20%, that means that CBV values that are more than 20% below the average CBV within the contralateral MCA territory are considered “reduced.”
CT Brain Shuttle Perfusion: Summary Maps

Click Perfusion Tools menu to close.

Check the Brain Midline for accuracy before turning on the Summary Maps.

Click Show checkbox in the Thresholds menu.

Check and adjust the brain midline on the top and bottom slices.
CT Brain Shuttle Perfusion: Summary Maps

The Summary map displays the affected anatomy. Unaffected tissues can be tinted green if desired.
Select the 3D/MPR format to display the affected tissue volumes.
CT Brain Shuttle Perfusion: Take Snapshot

Select **Snapshot**.

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Click in an image to create a snapshot for export. Images are stored in the **Report Page**.

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Click the Snapshot tool and while depressing the **alt** key, click images. Camera will not turn off until **alt** key is released.
CT Brain Shuttle Perfusion: Batch Collage

Right click on the image to display the menu options.

Select **Batch Collage**.

Image preview displays as the series is being generated. Batch is placed in the **Report Page** to be exported.
CT Brain Shuttle Perfusion: Export

Select Report.

Snapshots have no icon on the lower right corner. Batches have an icon.

Hold ctrl and select the snapshots.

Click Export.
Choose destination under Export To.

If exporting multiple snapshots, they must have the same series description. Click in the space next to Change all series descriptions and enter a series description.

If exporting multiple snapshots, click Export as single series button.

Do not export multiple batch series as a single series. The default selection will export batches as individual series.
Note to Users:

A limitation of the current perfusion method is that the MTT values cannot be computed reliably in areas of very low blood flow. This will usually appear as low MTT values in low CBV regions or in presumably newly infarcted brain regions. The apparent low MTT in regions with very low flow is more pronounced when the time attenuation curves are right-truncated because the scan starts too early compared to the contrast bolus arrival or generally when the scan ends before the end of the washout. This limitation is generic limitation of most delay corrected algorithms such as the one used in the Vitrea software (SVD+) Brain Perfusion. The summary maps take into account this limitation in the computation of the red areas.

Please Reference the Help Guide for more information.