Using CARE kV to Reduce Patient Dose and Optimize Image Quality

Description: This step by step document will assist the technologist in optimizing protocols to reduce the radiation dose to the patient while improving image quality using the CARE kV feature on the Biograph mCT scanners.

1. Topogram

One topogram is used to calculate the estimation of CAREDose curves. If using two topograms, perform the lateral acquisition first followed by the AP or PA acquisition. It is preferable to acquire in the PA position to reduce scatter radiation to the breasts.

The system will always use the last scanned topogram for modulation. It is not recommended to switch from using one to using two (or vice versa) without optimizing the protocol.
2. CARE kV Contrast/Noise Reference (CNR)

The CNR represents how much we can distinguish the structure we want to see from the background. It is defined for a particular Tissue of Interest (TOI).

**Contrast** - Dependent on the kV, attenuation and the TOI.  
**Noise** - Dependent on the kV, mAs, attenuation and the TOI.

Using CARE kV, we set a reference CNR by providing the system with all the information needed to calculate this.

**Attenuation:** Topogram  
**kV:** Reference kV  
**mAs** Reference mAs  
**TOI** Slider Position

**Note:**

CARE kV is based on the fact that when we use a different kV, the difference in HU (contrast) between the TOI and the background may change significantly. This will increase more for some tissues and less for others. The problem is that the noise will also increase. Adaptation is necessary to adjust the noise. The objective is to reduce the noise so that it will increase at the same ratio as the contrast. Therefore the CNR will be preserved.

Some tissues, especially ones with high contrast, will increase in contrast significantly by decreasing kV. For these tissues, the increase in noise is not apparent with respect to other surrounding tissues. For example: In a vessel with contrast, the average HU will increase significantly by decreasing the kV. This increase in contrast is much more apparent than seen in soft tissue or bone. The change in noise in a high contrast tissue is then comparable to the change seen in low contrast tissues. For some tissues, there is much change in the contrast, but the noise only has to be slightly re-adjusted. The tube is less stressed and the lower kV is often acceptable.
3. Slider Position

The slider position is simply depicting the tissue of interest in question.

The right side of the slider focuses on structures that have increased contrast by changing the kv. Examples of these tissues are ones that contain contrast media. The contrast will increase significantly by lowering the kV. If the slider is slid to the right, the tissue will have a higher change in contrast (lower kV) and a weaker mAS adaptation.

The left side of the slider focuses on structures that do not experience a lot change with contrast by changing the kv. The slider position must be set for every protocol and should not be changed for any patient.

Whenever the same kV is selected as the reference kV, there will be no change in HU. This will mean no contrast for every tissue. The CNR will always remain the same as the reference CNR and the noise remain the same. It’s likened to having the CARE kV off.

Example:

We could estimate how much the contrast is increasing by changing the kV. It would, however, be complicated to guess how the noise will change and how much correction is needed. Noise is proportional to the square root of the attenuation, divided by the current and the 3rd power power of the voltage. Changing the voltage will change the noise, but not linearly. It will also change the attenuation, which will again influence the noise. This example shows how difficult it would be to replace CARE kV with manual settings.
**CARE kV On:**

1. Among all the possible combinations, the one with the lowest dose is chosen.
2. If for that specific combination, the tube limit is reached, the next available combination is chosen.
3. If the same kV is chosen as the reference kV, there will be no improvement in the contrast respect to the reference contrast. There will be no change in noise level. This is equal to having CARE kV off.

**CARE kV Semi:**

1. Will force the system to use one specific kV.
2. If the same kV is chosen as the reference kV, there will be no improvement in the contrast with respect to the reference contrast. There will be no change in noise level. This is equal to having CARE kV off.

**CARE kV Off:**

1. Only CAREDose 4D will be used.

**4. Pitch and Effective mAs:**

If the pitch is less than 1, the x-ray beam profiles will overlap and the absorbed dose increases.

If the pitch is greater than 1, the x-ray beam profiles do not overlap and there are gaps in the acquisition. The absorbed dose decreases.

Effective mAs is representative of **Image Quality** and **Dose**. To keep it constant, we always have to increase and decrease the mAs in the same way as we increase and decrease the pitch.

**Example:**

200 Effective mAs is desired

<table>
<thead>
<tr>
<th>Pitch</th>
<th>mAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td>1.5</td>
<td>300</td>
</tr>
<tr>
<td>2</td>
<td>400</td>
</tr>
</tbody>
</table>
**Tips and Tricks**

1. Decreasing the pitch will keep the reference image quality.
2. Optimizing the slider position for specific types of exams will also change the reference CNR.
3. Optimizing CAREDose modulation curves will slightly change the image quality.
4. Using the Protocol Assistant, you can set the minimum or maximum kV use for each protocol.
5. To change the CAREDose for slim and obese adults, pull down **Options -> Configuration** and select **Examination Configuration**. This is also available for pediatric protocols.

**Typical Doses for Specific Protocols**

**Head Routine:**
120 kV, 340 mAs, 12 cm = 59.7 mGy or 1.5 mSv

**Thorax Routine**
120 kV, 120 mAs, 30 cm = 9.2 mGy or 3.9 mSv

**Abdomen Routine**
120 kV, 180 mAs, 30 cm = 13.8 mGy or 6.2 mSv