Coronary CTA Retrospective Protocol: More is Always Better?


Hospital Sírio-Libanês
São Paulo - Brazil
**BACKGROUND**

**Cardiovascular disease** is the leading cause of death worldwide. **Ischemic heart disease** is the leading cause of cardiovascular death, accounting for 9.44 million deaths in 2021.

80% of cardiovascular disease is preventable.

Coronary CT angiography (CCTA) is the main choice for cardiovascular risk stratification.

- High reliability
- High negative predictive value
- Non-invasive method

CCTA: Coronary Computed Tomography Angiography; CAD: Coronary Artery Disease; TCE: left coronary sinus; CD/RCA: right coronary artery; CX: circumflex artery; DA/ LAD: anterior descending artery
CCTA enables the comprehensive assessment of coronary artery anatomy in its entirety and across three-dimensional planes.

**CCTA: Anatomy Evaluation**

<table>
<thead>
<tr>
<th>Artery</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anterior descending artery</strong> (1)</td>
<td>Supplies majority of left ventricle</td>
</tr>
<tr>
<td><strong>Circumflex artery</strong> (2)</td>
<td>Supplies left ventricle free wall and portion of anterolateral papilar muscle</td>
</tr>
<tr>
<td><strong>Right coronary artery</strong> (3)</td>
<td>Supplies right ventricle</td>
</tr>
</tbody>
</table>
The main challenge in CCTA is to immobilize heart motion to capture images of the coronary arteries throughout the cardiac cycle.

### Retrospective ECG triggering mode (Helical mode)
- Higher radiation
- Radiation projection data from specific points within the R-R interval are selected for image reconstruction

### Prospective ECG triggering mode (Sequential mode)
- Lower radiation
- X-rays are turned only at predetermined R-R intervals

<table>
<thead>
<tr>
<th>Radiation projection data from specific points within the R-R interval are selected for image reconstruction</th>
<th>X-rays are turned only at predetermined R-R intervals</th>
</tr>
</thead>
</table>

**BACKGROUND**

Throughout the entire CCTA acquisition process, the subject's ECG is continuously recorded, and image reconstruction is synchronized with heart motion through ECG triggering.

- **Diastolic phase**: Most quiescent part of cardiac cycle
- **High temporal resolution**
- **High spatial resolution**
Prospective ECG triggering method

Retrospective ECG triggering (Helical mode)  Prospective ECG triggering (Sequential mode)

Because X-ray is turned all over the cardiac cycle in retrospective ECG triggering method, reconstruction in different phase in R-R interval is possible in cases of increase heart rate (HR), extrassystoles, arrythmia or breath motion artifacts.

CCTA retrospective acquisition and patient ECG. Image on the right shows an artifact due to an extrassystole during image acquisition, compromising RCA (*) study.

RCA study was possible when selected a different phase to image reconstruction.
From February 1st to July 31st, adjustments were made to optimize protocols, enhancing the quality of retrospective-mode CCTA images and reducing radiation exposure.

**Use of Beta-blocker medications**
Reduce patient’s HR (longer diastolic phase)

| Succinate metaprolol | Intravenous (IV) or Oral | \(\beta_1\) selectivity | **Contra indications:** asthma on beta-agonist inhalers and active bronchospasm
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ivabradine</strong></td>
<td>Oral</td>
<td>selectively suppresses the activity of sinoatrial node cells.</td>
<td></td>
</tr>
</tbody>
</table>

**Use of Automatic Exposure Control and BMI patients protocols**

*Care dose 4D* is responsible for tube-current modulation according to different anatomical regions and patient BMI. *Care kV* provides the requested image quality while minimizing dose to the patient.

5 protocols categories according to patients BMI (mAs and kV values according specific for each protocol)

**Vessel dilator (Isordil)**

Improve RCA visualization

**Contra indications:** Use of PDE-5 inhibitor drugs: sildenafil (Viagra), vardenafil (Levitra) and tadalafil (Cialis) can cause severe hypotension

**Interative reconstruction (IR)**

Algorithms reconstructions developed to overcome filtered backprojection

- Higher spatial resolution
- Lower image noise

*BV 36 + ADMIRE strength 2*  
*BV 40 + ADMIRE strength 3*
In retrospective ECG triggering mode scan data are collected throughout the heart cycle.

R-R range is the maximum tube current.

Phase selected to image reconstruction.

Phantom trial using 3 different R-R ranges during a CT ECG triggered acquisition demonstrates differences in DLP values according to different R-R ranges.

<table>
<thead>
<tr>
<th>Scan</th>
<th>kV</th>
<th>mAs</th>
<th>/ ref.</th>
<th>CTDiw/tr</th>
<th>DLP</th>
<th>TI</th>
<th>cSL</th>
</tr>
</thead>
<tbody>
<tr>
<td>T ARR 70-80</td>
<td>32D</td>
<td>110</td>
<td>208 / 340</td>
<td>58.56</td>
<td>2058.3</td>
<td>0.25</td>
<td>0.6</td>
</tr>
<tr>
<td>T ARR 60-80</td>
<td>33D</td>
<td>110</td>
<td>238 / 340</td>
<td>66.93</td>
<td>2351.6</td>
<td>0.25</td>
<td>0.6</td>
</tr>
<tr>
<td>T ARR 40-80</td>
<td>34D</td>
<td>110</td>
<td>260 / 340</td>
<td>78.78</td>
<td>2768.1</td>
<td>0.25</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Larger R-R range, longer exposure to maximum tube current, higher DLP.

In 120 CCTA examinations, we observed the average phase chosen by CT scanners during retrospective mode acquisitions at varying heart rates on two dual-source CT scanners:

Flash: 74% and Force: 70% (Siemens)

Established R-R ranges according to average phase selected observed.

Team awareness (physicians, technologists) about the radiation exposure increase when selecting larger R-R ranges.

Flash: 67%-80%  Force: 70% -80%
Fixed R-R ranges in retrospective acquisition mode

As a result, we noted a decrease in the DLP during retrospective CCTA acquisitions after implementing shorter R-R intervals for both dual-source CT scanners employed for CCTA examinations.

Optimizing the retrospective protocol parameters led to enhanced image quality and a decrease in patient radiation exposure during CCTA examinations.

Boxplot graphics showing DLP values before (left) and after (right) R-R ranges alterations in CT dual source scanners (FORCE and FLASH). After established shorter R-R ranges, the graphics indicate DLP median values reduction, from 600 to 400mGy.cm and more concise values around the new median DLP values.

CCTA retrospective acquisition with breath artifact compromising RCA (*) study. After selecting a different reconstruction phase according to the established R-R range, a new image was obtained without artifacts in RCA. There was no need to repeat the acquisition and media contrast re-injection.

Take home messages
- Team awareness and education and protocol parameters optimization

What is the main objective?
- Optimizing the retrospective protocol parameters to enhance image quality and decrease radiation exposure.

How can we achieve it?
- Selecting different reconstruction phases according to established R-R ranges.
REFERENCES


Thank You!
Contact: Larissa.marciano72@gmail.com