Low-dose CT coronary angiography: Role of adaptive statistical iterative reconstruction (ASIR)

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Authors: M. A. Glazkova, I. Arkhipova, V. Sinitsyn, E. A. Mershina; Moscow/RU
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Purpose

Coronary CT angiography (CTA) is an accurate method for the noninvasive detection and follow-up of the patients with coronary artery disease. This method had been criticized for high radiation exposure to patient. The use of modern technology of an adaptive statistical iterative reconstruction (ASIR) can reduce the tube voltage (100 kV and less), that can decrease the radiation dose, but there are concerns about image quality.

Purpose of Study

To determine the effect of ASIR-algorithm on radiation dose and image quality for coronary CT angiography (CTA).

Methods and Materials

57 patients undergoing CTA were prospectively included into the analysis. All patients with a resting HR higher than 85 bpm received 15-20 mg metoprolol 15-20 minutes before the coronary CTA examination.

Exclusion criteria for this study were following:

(a) frequent extrasystoles;
(b) renal insufficiency with creatinine level >1,5 mg/dl;
(c) allergy to iodinated contrast agents;
(d) severe heart failure (NYHA III-IV);
(e) pregnancy.

Examinations were performed with 2 types of 64-row scanners using retrospective ECG-gating. The results of 27 patients were reconstructed with filtered back projection (FBP) (group I) and 30 patients - with ASIR-algorithm (40 %) (group II). Characteristics of the patients (age, heart rate, BMI) were not statistically different between the two groups (Table 1). The CTA examinations using ASIR-algorithm were done with lower tube voltage than those using FBP (100 kV and 120 kV, resp.; p < 0,0001).

According to the vendor's recommendations, we used 40% ASIR and 60% FBP image reconstruction for the 2-nd group. The phantom's analysis results also showed that 40% ASIR-algorithm should produce a diagnostically acceptable image with less noise than
a full-dose FBP, but without artificial smoothing of 100% ASIR-algorithm (Fig. 1 on page 3).

**Tab. 1 Patient’s characteristics and CTA acquisition for two groups (group I - FBP; group II - 40 % ASIR-algorithm).**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Group I (n=27)</th>
<th>Group II (n=30)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age¹</td>
<td>61±9,65</td>
<td>61±10,9</td>
<td>0,54</td>
</tr>
<tr>
<td>Mean heart rate (beats/min)¹</td>
<td>62,7±8,3</td>
<td>59±8,9</td>
<td>0,71</td>
</tr>
<tr>
<td>Slice collimation</td>
<td>64 × 0,625 mm</td>
<td>64 × 0,625 mm</td>
<td>-</td>
</tr>
<tr>
<td>Tube voltage (kV)</td>
<td>120</td>
<td>100</td>
<td>0,0001</td>
</tr>
<tr>
<td>Tube current (mA)¹</td>
<td>535±30,57</td>
<td>596±10,2</td>
<td>0,001</td>
</tr>
</tbody>
</table>

¹ Mean±SD

Patients received an intravenous injection of 80 - 100 ml contrast medium (ioversol, 350 mgl/ml) with a rate 4-5 ml/s.

We measured contrast level, image noise, signal-to-noise ratio (SNR) of ascending aorta, myocardium, left ventricular cavity and pulmonary trunk (Fig. 2 on page 4).

Effective radiation doses were calculated using volume CT dose index (CTDIvol) and dose-length product (DLP) with a conversion coefficient 0,014 mSv/ mGy*cm.

**Images for this section:**

**Fig. 1:** Effect of ASIR-algorithm on image noise. a. FBP reconstruction at half dose. b. 100% ASiR. c. 50% ASiR.
Fig. 2: Measurement of the contrast level (HU), image noise (HU) and signal-to-noise ratio (SNR) at the root of ascending aorta. The region of interest (ROI) was defined as 100 mm².
Results

Contrast level, image noise, SNR of an ascending aorta, pulmonary artery, left ventricular (LV) myocardium and cavity were not statistically different between the FBP- and ASIR-groups (Tab. 2, Fig. 3 on page 6).

Tab. 2 Image noise and SNR in various anatomical ROI in FBP- and ASIR-groups.

<table>
<thead>
<tr>
<th>ROI</th>
<th>Image noise</th>
<th>SNR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FBP</td>
<td>ASIR</td>
</tr>
<tr>
<td>Ascending aorta</td>
<td>42,6</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>[15,53]</td>
<td>[21,87]</td>
</tr>
<tr>
<td>LV myocardium</td>
<td>46</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>[16,7]</td>
<td>[15,7]</td>
</tr>
<tr>
<td>LV cavity</td>
<td>45,7</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>[19]</td>
<td>[24,38]</td>
</tr>
<tr>
<td>Pulmonary artery</td>
<td>43</td>
<td>42,9</td>
</tr>
<tr>
<td></td>
<td>[21]</td>
<td>[13]</td>
</tr>
</tbody>
</table>

¹median [interquartile ranges]

Application of ASIR-algorithm significantly improved overall images quality, especially in obese patients (Fig. 4 on page 6).

There was 45.9 % reduction in the median [interquartile ranges] radiation dose between the ASIR- and FBP-groups (8,7 [3,5] mSv vs 16,1 [1,4] mSv, resp.; p < 0,0001). The values of CTDIv, DLP and E are shown in Table 3.

Calculated CTDIv and DLP were 46 and 47 % lower for ASIR-algorithm, than those for FBP-reconstruction.

Tab. 3 Characteristics of the radiation exposure for FBP- and ASIR-groups.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>FBP (n=27)</th>
<th>ASIR (n=30)</th>
<th>#-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTDIv (mGy)¹</td>
<td>66 [7,6]</td>
<td>35,2 [7,6]</td>
<td>0,0001</td>
</tr>
<tr>
<td>DLP (mGy *cm)¹</td>
<td>1151 [101]</td>
<td>606, 52 [279,7]</td>
<td>0,0001</td>
</tr>
</tbody>
</table>
Using of 40% ASIR-algorithm could reduce radiation dose by 45.9% without significant image quality change (Fig. 5 on page 7 Fig. 6 on page 7).

Images for this section:

**Fig. 3:** FBP (a) and ASIR (b) reconstructions at the level of ascending aorta. Image noise in the ROI was lower in images reconstructed using ASIR-algorithm (circle in fig. b) compared with those reconstructed using FBP (circle in fig. a).
Fig. 4: 40 % ASIR-algorithm. Images of obese patient (BMI = 28.9 kg/m2). Effective radiation dose was 4.5 mSv.

Fig. 5: Comparison of two reconstruction algorithm: 40 % ASIR (a) and FBP (b). Effective radiation dose was 7.3 mSv for 40 % ASIR-algorithm (a) and 16 mSv for FBP reconstruction (b). There was 54.3% dose reduction at 40 % ASIR-algorithm without image quality change.
Fig. 6: 40 % ASIR-algorithm : SSD, curved MPR of coronary arteries at 8 mSv , with excellent image quality
Conclusion

Coronary CTA using 40 % ASIR is accompanied with significant decrease of radiation dose without loss of image quality.

References


Personal Information

Maria A. Glazkova 1
Student
e-mail: mary-ga@yandex.ru

Irina M. Arkhipova, MD 1
Radiologist
e-mail: iarkhipova77@mail.ru

Elena A. Mershina MD., PhD 1
Associate Professor of Radiology
e-mail: elena_mershina@mail.ru

Valentin E. Sinitsyn, MD, ScD 1
e-mail: vsini@mail.ru

1 Radiology Department
Federal Center of Medicine and Rehabilitation

Ivankovskoe shosse 3, Moscow 125367, Russian Federation