Post-EVAR endoleak detection: low-dose model-based iterative reconstruction (MBIR) Veo™ vs adaptive statistical iterative reconstruction (ASIR™) CTA-a prospective study

<table>
<thead>
<tr>
<th>Poster No.:</th>
<th>C-0283</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congress:</td>
<td>ECR 2015</td>
</tr>
<tr>
<td>Type:</td>
<td>Scientific Exhibit</td>
</tr>
<tr>
<td>Authors:</td>
<td>R. Perignon, M. Fontarensky, A. Mulliez, A. Petermann, T. Maumias, L. Boyer, L. Cassagnes; Clermont-Ferrand/FR</td>
</tr>
<tr>
<td>Keywords:</td>
<td>Dosimetric comparison, Aneurysms, Diagnostic procedure, CT-Angiography, Radioprotection / Radiation dose, Vascular</td>
</tr>
<tr>
<td>DOI:</td>
<td>10.1594/ecr2015/C-0283</td>
</tr>
</tbody>
</table>

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Aims and objectives

Aortic aneurysm is a common disease with serious, often fatal complications (including rupture, providing high morbidity and mortality). It is recognized that after a certain aortic diameter, preventive treatment reduces mortality(1). Endovascular aneurysm repair (EVAR) has become the preferred method of treatment in many centers (2)(3), but it is not without complications, chiefly endoleak that remains a lifelong risk.(4) (5)(6) Patients thus require at least one follow-up visit per year, where surveillance is often a CT angiography (CTA) with the associated substantial exposure to ionizing radiation.

This follow-up induces an increase in radiation dose delivered to patients and subsequent risks of low-level-radiation-induced cancer (as cumulative effective dose reaches worrying levels) (7)(8)

In an effort to reduce exposure to ionizing radiation during CT exploration, some authors have attempted to remove one phase, primarily the arterial phase (9) (10) but a recent study tried to remove the noncontrast phase with dual-energy CT (11).

An alternative method to cut dose is to reduce dose per image (reducing the CTDI) by using new iterative reconstruction algorithms.(12)(13)

First- and second-generation iterative reconstruction techniques have already reduced dose exposure, and the advent iterative reconstruction based on the third-generation Veo™ model-based iterative reconstruction (MBIR) algorithm presages further reductions of dose to patient compared to second-generation adaptive statistical iterative reconstruction (ASIR) with standard acquisition dose (14). A recent study evaluated image quality with MBIR Veo™ for endoleak detection (15) but not the diagnostic performance of this method.

The purpose of the study reported here was to evaluate low-acquisition dose MDCT with MBIR (VEO™) versus standard-dose CT angiography (CTA) using second-generation iterative reconstruction ASIR™ (now the reference standard) monitoring of endovascular aneurysm repair (EVAR) of abdominal aortic aneurysm for endoleak detection (and classification).
**Methods and materials**

We led a monocentric retrospective review of prospective acquired data at Gabriel Montpied University Hospital, Clermont-Ferrand (France). Our local IRB approved the study, and written informed consent was obtained from each patient.

**Population:**

76 Patients aged between 18 and 90 years old undergoing CTA examination for EVAR follow-up were asked for informed consent. General exclusion criteria were nephropathy, adverse reactions to iodinated contrast medium, and pregnancy. 8 patients refused the protocol, 1 was excluded due to cognitive impairment liable to interfere with informed consent, and 2 were excluded due to renal failure. The vast majority of patients were referred to us by the vascular surgery department.

**CT protocol and image reconstruction:**

Each patient received both technical reconstructions the same day at the same time.

We performed a triphasic protocol with unenhanced phase, arterial phase and delayed phase that represents the reference-standard protocol.

**CT protocol:**

CT examinations were obtained on a single-source 64-slice MDCT system (Discovery 750 HD, General Electric, Milwaukee, WI).

Parameters used are detailed in Table 1. -Both acquisitions were made on strictly identical segments (same volume acquisition)

The CT protocol is detailed in Figure 1.
Low-dose ASIR reconstruction was performed to verify the coverage of the CT exploration and to ensure absence of patient movement and better interpretability of the examinations.

Low-dose VEO unenhanced phase acquisition was performed to compare comparable series.

In this way, all analyzed series came from the same reconstruction method, and the evaluation of Veo CT reconstruction was not influenced by the ASIR images. All artifacts were similar as resulting from the same reconstruction.

Concerning the arterial phase, it was impossible to lead both acquisitions with a good arterial phase without a second injection of contrast medium. We ruled out the idea of a second injection as most of the patients presented moderate renal failure or polyvascular disease. Many studies have tried to remove the arterial phase (16)(17) while others suggest it is doable in follow-up and not at the first evaluation (18). We elected to keep the arterial phase in order to compare Veo under a triphasic and reference-standard protocol. The CTDI for VEO acquisitions was divided by 2.

**Injection protocol**

Patients received 120 mL of iodinated contrast medium (Iopromide, Ultravist 370 mg i/mL, Bayer®) at a flow rate of 4 mL/s followed by a chaser bolus of 40 mL saline solution at a 4 mL/s.

**Diagnostic evaluation**

The examinations were interpreted on an Advantage Workstation (GE Healthcare, Milwaukee, WI) with reformation in different planes by two senior radiologists with 10 (LC) and 5 (RP) years' experience in vascular radiology.

All examinations were interpreted blindly and independently to other series, other observer and patient report. The only known variable was maximum diameter of the aneurysm and its variation since the previous review. The techniques were not compared on measurement of aortic diameters as other studies have demonstrated the absence of variation(15).

The primary endpoint was the detection of endoleaks, but we also analyzed type of endoleak, visibility in the arterial and delayed phase, or other possible complications (kinking, thrombosis, infarction, migration, etc.) as secondary endpoints.
Endoleak detection began by looking at the delayed phase. The arterial phase was used to determine type of endoleak, after analysis of the delayed phase.

**Dose exposure**

Dose was available on the examination report. CT dose index (CTDI) was expressed in mGy and dose-length product (DLP) was expressed in mGy.cm.

Size-specific dose estimates (SSDE) was calculated using effective diameter determined in the middle of the acquisition of the CT evaluation, according to the report of AAPM Task Group 204.

Effective dose (ED), expressed in mSv, was calculated from the tissue weighting factor for the abdomen and pelvis ($k = 1.5 \times 10^{-2}$) using the formula $DE = k \times PDL$ (19, 20).

**Evaluation of image quality**

The VEO™ MBIR gave a smoother render requiring a learning curve for interpretation (21, 22). To understand the impact of the image rendering, it proved necessary to focus on objective image quality and quantitative quality with measurement of the noise.

**Objective image quality**

Objective image quality was assessed by measurement of the noise in the three reconstructed series (standard-ASIR™/Low-dose ASIR™/Low-dose VEO™) and was achieved by implementing a 10 mm-diameter circular region-of-interest (ROI) in the abdominal aorta at the celiac trunk on an axial section by the same radiologist. Noise was defined as the average standard deviations. Signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) were studied.

**Subjective image quality**

After a period of adjustment, the subjective image quality was assessed based on 3 levels (good, average, poor quality), and focused on the delayed phase.
Statistical analysis

Data were analyzed using STATA V12 software (StataCorp, College Station, TX). All tests were considered with a first-type risk of 5% (two-sided). Threshold for a statistically significant difference was set at $p < 0.05$.

Qualitative variables were described in terms of staffing and related percentages, and quantitative variables in terms of means and standard deviations.

Qualitative vs quantitative evaluations of image quality were compared using the Fisher’s exact test and a Student $t$-test. Mean image quality scores was compared by a Kruskal-Wallis test. Intraobserver agreement between the two reconstructed series (Standard ASIR™ and Low-dose VEO™), and interobserver agreement were measured using the kappa test with presentation of the corresponding kappa correlation coefficients (23).

Intrinsic values (sensitivity/specificity and PPV/NPV) of "low-dose Veo™ MBIR" vs "standard ASIR™ acquisition" (considered reference standard) series are reported with 95% confidence intervals.
Table 1: Acquisition and image reconstruction parameters.

© - Clermont-Ferrand/FR
Fig. 1: CT protocol

© - Clermont-Ferrand/FR
Results

Prior informed consent was obtained from all patients. From February 2013 to February 2014, 93 examinations were performed as per acquisition protocol. A data loss event meant that 13 examinations had to be excluded despite every effort to recover the lost data. We therefore analyzed 160 examinations (80 examinations × 2) from 76 patients (4 patients were examined twice over the course of the study period). All explorations took place without incident.

Mean body mass index (BMI) was 26.96 kg/m² (range: 18.4-40 kg/m²). Mean patient age was 72.05 years (range: 47-87 years). Key characteristics of the population are detailed in Table 2.

Dosimetric results

Dose reduction

Mean CTDI (±SD) for the Veo™ delayed series was 5.14 (±1.62; range: 3.1-8.83) mGy vs 11.14 (±3.52; range: 7-18.08) mGy for the ASIR™ standard series. Mean DLP for the Veo™ delayed series was 278.46 (±95.9; range: 136-505) mGy.cm vs 604.31 (±213.81; range: 249-1028) mGy.cm for the standard ASIR™ series, i.e. a 2.17-fold decrease in effective exposure.

Mean SSDE for the Veo™ delayed series was 6.03 (±1.65; range: 3.32-13.27) mGy.cm vs 13.06 (±3.47; range: 6.78-30.38) mGy.cm for the standard ASIR™ series.

The mean effective diameter was 31.04 (±3.57; range: 23-40) cm

Effective dose thus amounted to 4.17±1.43 (range: 2.04-7.57) mSv with Veo™ vs 9.06±3.20 (range: 3.73-15.42) mSv with ASIR™.

Image quality

Veo had a higher signal-to-noise ratio and contrast-to-noise ratio than ASIR (Figure 2).
According to the first reader, average subjective quality was better on low dose examination, at 1.86 against 1.75 for standard acquisition. A small adjustment was deemed necessary due to the different image rendering, especially between the axial and other planes (sagittal and frontal). After an adaptation period, the images appeared clear and smoothed, and with greater contrast. There were fewer hardening artifacts with Veo™ (Figure 3).

According to the second reader, average subjective quality was better on standard acquisition, but with results that differed only for 6 exams (7.5%).

Interobserver agreement is detailed in Table 3. One unconformity was found in both readers. Reader 2 missed one endoleak with the low-dose Veo™ acquisition. This same endoleak was missed in the first interpretation but picked up at consensual reading by both readers (and classed as type-II).

Reader 1 could not see one endoleak on the standard-dose ASIR acquisition (reference standard). We ultimately ruled that this was not a false-positive of Veo™ but a false-negative of ASIR™ acquisition. The ASIR™ scanner failed to find this endoleak (even after consensual reading) whereas a previous CT examination of this patient (PACS archive) clearly showed a type-II endoleak at this level.

Initially, we should have studied the impact of BMI on endoleak detectability but the excellent concordance results meant that there were too few false-positives to study this parameter.

Consensual reading did not miss any endoleaks in the Veo acquisition.

This study found two misclassifications of type-II endoleaks: (a) the first was due to bad visualization of the causal artery in the ASIR evaluation and was correctly evaluated in the Veo acquisition (Image 1); (b) the second was classed a type-III endoleak in the Veo acquisition but reclassified as type-II after consensual reading.

No differences in detection were found on other EVAR complications.
### CHARACTERISTICS OF THE POPULATION. n = 80 patients .76 examinations

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>men 73 (96%) women 3 (4%)</td>
</tr>
<tr>
<td>Age</td>
<td>72 ± 8.5 (47–87) years</td>
</tr>
<tr>
<td>Weight *</td>
<td>82 ± 155 (50–125) kg</td>
</tr>
<tr>
<td>Height</td>
<td>174 ± 0.08 (152–196) cm</td>
</tr>
<tr>
<td>BMI</td>
<td>26.96 ± 4.1 (18.4–40.8) kg.m²</td>
</tr>
<tr>
<td>&lt;24.9: Underweight + normal weight</td>
<td>Number of patients: 24 (31.6%) Number of examinations: 26</td>
</tr>
<tr>
<td>25–29.9: Overweight</td>
<td>Number of patients: 37 (48.7%) Number of examinations: 38</td>
</tr>
<tr>
<td>&gt;30: Obesity</td>
<td>Number of patients: 15 (19.7%) Number of examinations: 16</td>
</tr>
<tr>
<td>Endoleaks</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>- 4 type 1</td>
</tr>
<tr>
<td></td>
<td>- 32 type 2</td>
</tr>
<tr>
<td></td>
<td>- 0 type 3</td>
</tr>
</tbody>
</table>

Quantitative data are given as mean ± standard deviation (min–max range)

**Table 2**: Characteristics of the population

© - Clermont-Ferrand/FR
Fig. 2: Subjective quality

Table 3: Results and agreement on the research of endoleaks.

© - Clermont-Ferrand/FR
Fig. 3: Missed endoleak with ASIR. Blue arrow show the type II endoleak. Red arrow show the causal artery. Note the fewer hardening artifacts with VEO.

© - Clermont-Ferrand/FR
Fig. 4: Patient with 2 endoleaks type I and II. Red arrow show the type I endoleak. Green arrow show the type II endoleak from a lumbar artery. Note the finding of a small bowel neoplasm (yellow arrow).

© - Clermont-Ferrand/FR
Conclusion

This blinded prospective study of 80 CT examinations showed that a third-generation model-based iterative reconstruction (Veo™) reliably enabled a 50% dose reduction without loss of diagnostic performance and with at least as good image quality. No endoleaks were missed by the Veo™ scanner after consensual reading. Subjective quality was essentially identical (Veo™ 1.84 vs ASIR™ 1.82), while the objective quality was superior with Veo™ (SNR: 7.84±2.68 vs 5.14±2.68 and CNR: 5.26±1.91 vs 3.11±2.20; p <0001).
Personal information

Renan PERIGNON, MD
Department of Radiology
Service de Radiologie
CHU Gabriel Montpied
58 Rue Montalembert, 63000 Clermont-Ferrand
rperignon@chu-clermontferrand.fr

Mikael FONTARENSKY, MD
Service de Radiologie
CHU Gabriel Montpied
58 Rue Montalembert, 63000 Clermont-Ferrand
mfontarensky@chu-clermontferrand.fr

Aurélien MULLIEZ
Direction Régionale de la Recherche Clinique et Innovation
CHU Gabriel Montpied
Villa Annexe IFSI - Rue Montalembert
63000 Clermont-Ferrand

Antoine PETERMANN, MD
Service de Radiologie
CHU Gabriel Montpied
58 Rue Montalembert, 63000 Clermont-Ferrand

Thibaut MAUMIAS, MD
Service de Chirurgie Vasculaire
CHU Gabriel Montpied
58 Rue Montalembert, 63000 Clermont-Ferrand

Louis BOYER, PhD
Service de Radiologie
CHU Gabriel Montpied
58 Rue Montalembert, 63000 Clermont-Ferrand
lboyer@chu-clermontferrand.fr

ISIT, UMR CNRS 6284 - Université d’Auvergne Clermont1

Lucie CASSAGNE, MD
Service de Radiologie
CHU Gabriel Montpied
58 Rue Montalembert, 63000 Clermont-Ferrand
lcassagnes@chu-clermontferrand.fr

ISIT, UMR CNRS 6284 - Université d’Auvergne Clermont1
References


