MSCT Coronary Angiography in Diagnosis of Chronic Coronary Occlusions

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The aim of the study was to evaluate the use of MSCT coronary angiography in the diagnosis of coronary artery occlusions.

Materials and Methods. Fifty-six patients (mean age 51.7±3.0 years) were examined for coronary artery occlusions by selective coronary angiography (SCG) and MSCT coronary angiography. We followed the recommendations of the multicenter J-CTO trial (Multicenter CTO Registry, Japan) based on the SCG data, as well as their proposed scale for predicting the outcome of endovascular recanalization. The latter scale was modified in line with our own results of MSCT coronary angiography as an independent method of visualization.

Results. The tomographic approach tested in this study was superior over the traditional invasive SCG in respect to the assessment of calcification, the length and the profile of the occlusion. The SCG was more advantageous in determining the shape and the size of the occluded artery stump and assessing the presence of a collateral network.

When combined, the predictive power of these two methods provides an additional 10% of successful recanalization.

MSCT coronary angiography can be an independent non-invasive method for diagnosing occlusive coronary disease and should be incorporated in the algorithm of patient examination prior to endovascular recanalization.

Key words: MSCT coronary angiography; selective coronary angiography; chronic occlusions of coronary arteries; non-invasive diagnosis of coronary arteries.

Introduction

Chronic occlusions comprise about one-fourth of all forms of atherosclerotic lesions of coronary arteries; they are considered the most “unsuitable” lesions for endovascular correction [1, 2].

Along with the increasing number of successful endovascular procedures for coronary atherosclerosis, the success rate of chronic occlusion recanalizations is still less than one-third and is associated with a high risk of intraoperative complications [3, 4]. This is due to the insufficient or inadequate (about 74%) diagnostic visualization of the occluded and the downstream segments of the artery when the invasive selective coronary angiography (SCG) is used [5, 6].

In the cases of coronary stenosis, the visualization power of SCG is indisputable but it remains insufficient in the case of coronary artery occlusions [7, 8]. Among these drawbacks, the sub-optimal quality of visualization in respect to the shape of the vessel stump, the extent of the occlusion, and the calcification volume of the occluded segment; poor or insufficient visualization of the distal parts of the native coronary artery and the status of collateral networks [9, 10]. At the same time, when combined, the above criteria help predict the success of endovascular correction of coronary artery occlusions [4, 10].

The indications developed elsewhere for selecting patients by the angiographic characteristics of the occlusive segment based on international scales undoubtedly increase the number of successful endovascular interventions, but so far it does not exceed 50–65% [1, 10].

The idea of using MSCT for coronary angiography has been floated in the recent 10 years [7, 8]; in this period, the number of these MSCT-based diagnostic procedures is increasing with years. The rapid progress of technical capabilities, the software and the post-processing options of up-to-date 64-slice tomographs provides a solid base for using MSCT coronary angiography as an alternative or complementary method for evaluating coronary arteries [9].

However, until recently, the MSCT method has not been applied to the diagnosis of coronary artery occlusions, which represent the most complicated atherosclerotic disorder of coronary arteries. To date, only a few publications on that subject can be found [1, 10].

In the present study, we followed the recommendations of the multicenter J-CTO (Multicenter CTO Registry, Japan) study [1] based on the SCG data,

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as well as their proposed scale for the prognosis of endovascular recanalization; for the first time, we used the results of MSCT coronary angiography to modify this primary scale and test its prognostic potential.

The aim of the study was to assess the informative potential of MSCT coronary angiography in assessing the state of occlusive coronary lesions and to determine the prognostic role of MSCT coronary angiography as an independent imaging modality. We also aimed to carry out a comparative analysis of MSCT vs SCG for their power of predicting the success of endovascular recanalization of coronary artery occlusions.

Materials and Methods

In this study, 56 patients diagnosed with chronic coronary artery occlusions were examined; among them, 35 males (63%) and 21 females (37%); the mean age of the subjects was 51.7±3.0 years (32 to 78 years).

The study was conducted in accordance with the Helsinki Declaration (2013) and approved by the Ethics Committee of the Specialized Cardiosurgical Clinical Hospital. An informed consent was obtained from each patient.

MSCT coronary angiography was performed using a computer tomograph (Aqullion CXL; Toshiba, Japan) and a multimodal workstation Vitrea (Toshiba, Japan) designed for image post-processing. Along with MSCT, all patients underwent the conventional invasive SCG procedure. The results of SCG added no significant information about the occluded artery; the SCG test was run rather traditionally.

In order to maintain the reliability of the results, the time interval between the two tests did not exceed 3 months.

According to the accepted Agatston standard, the coronary calcium in the occluded artery was quantified before performing of the MSCT coronary angiography.

As a basis for evaluating and comparing the results of MSCT (non-invasive method) and SCG (invasive method), we used the characteristics of the occluded segment presented in the J-CTO study [1]. Our own contribution included the detailed description of calcification in the pre-occluded, occluded and post-occluded segments of the artery, the assessment of the collateral network, as well as the evaluation of the real extent of the occlusion, and the presence/absence of multi-segment occlusions.

Results and Discussion

A comparative analysis of the two imaging methods indicates that the sensitivity of MSCT coronary angiography in detecting the coronary calcium (Ca score) exceeds that of the SCG by about one third (see the Table); in detecting Ca deposits, the sensitivity of MSCT reaches 97%.

In determining the length of the occluded segment, the MSCT is superior to the SCG also by one third; in this capacity, the MSCT sensitivity reaches 61% (Figure 1).

The MSCT method showed better results (as compared with SCG) in the diagnosis of multi-segment occlusions (the MSCT sensitivity was 34 vs 18% with SCG); in determining the tortuosity of the occluded segment, the MSCT sensitivity was 23 vs 16% with SCG.

The SCG, however, was more efficient than the MSCT in determining the shape and the size of the stump and assessing the presence of a collateral network.

Based on the cumulative results of the invasive (SCG) and non-invasive (MSCT) methods, we were able to define three groups of patients.

Group 1 (n=20) — very difficult for endovascular correction. This includes the patients who had two or

Imaging with either MSCT coronary angiography and selective coronary angiography applied to the diagnosis of coronary artery occlusion (abs. number/%)

Parameters of the occluded artery	Applicability of selective coronary angiography	Applicability of MSCT	Poor visualization with either method	p
The presence of stump	41/23	36/20	59/33	<0.05
The presence of calcium in the structure of occlusion	31/17	96/54	4/2	<0.05
The presence of calcium in the pre-occlusion segment	54/30	98/55	2/1	<0.05
The presence of calcium in the post-occlusion segment	24/13	96/54	4/2	<0.05
The length of occlusion	28/16	61/34	39/22	<0.05
Tortuosity of the occluded segment	16/9	23/13	77/43	<0.05
Expression of the collateral network	61/34	41/23	39/22	<0.05
The presence of multi-segment occlusion	18/10	34/19	66/37	—

Note. For comparing the measurable parameters with normal distribution, the Student's t-test was used.

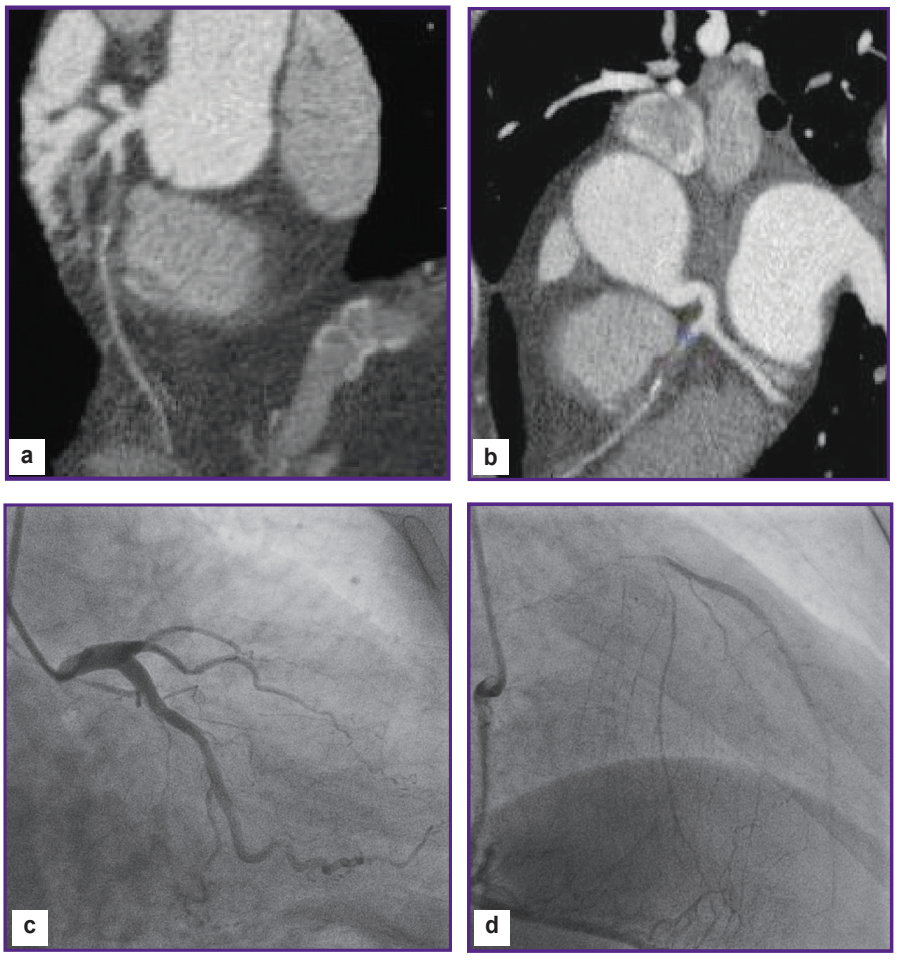

Figure 1. Comparison of the ECG-synchronized MSCT coronary angiography images in high-resolution mode with slices of 128×0.25 mm and the selective coronary angiography (SCG) images: occlusion of the anterior descending artery (ADA):
(a), (b) MSCT coronary angiography; occlusion of the proximal segment of ADA with a "soft" plaque; the length of the occluded segment is up to 2 cm; no collateral network is expressed; (c), (d) invasive SCG; occlusion of the proximal segment of ADA

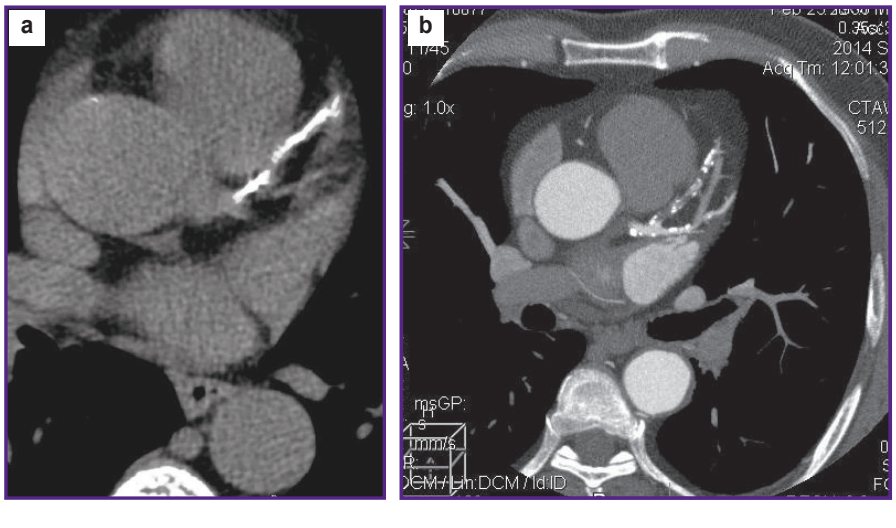

Figure 2. ECG-synchronized MSCT coronary angiography in high-resolution mode with slices of 128×0.25 mm in patients of group 1 (high risk): occlusion of the anterior descending artery (ADA):
(a) Ca score; extended calcification of the proximal and middle segments of ADA (the Agatston index >400 according to the Ca score); (b) MSCT coronary angiography; extended (more than 2 cm) occlusion of the proximal segment of ADA with uneven calcification

more risk factors: double- or multi-segment occlusion, massive calcification of the occluded segment (above 300 units), the occluded segment longer than 2 cm (Figure 2).

Group 2 (n=27) — readily suitable for recanalization; this includes the patients who had none of the above-mentioned risk factors (Figure 3).

Group 3 (n=9) — the intermediate (or unclear) condition, i.e. the patients who had one of the above risk factors (Figure 4).

Thus, based on the combined assessment (MSCT+SCG) of the coronary bed in these patients, we could weigh the chances for successful recanalization according to the proposed algorithm (Figure 5); then,

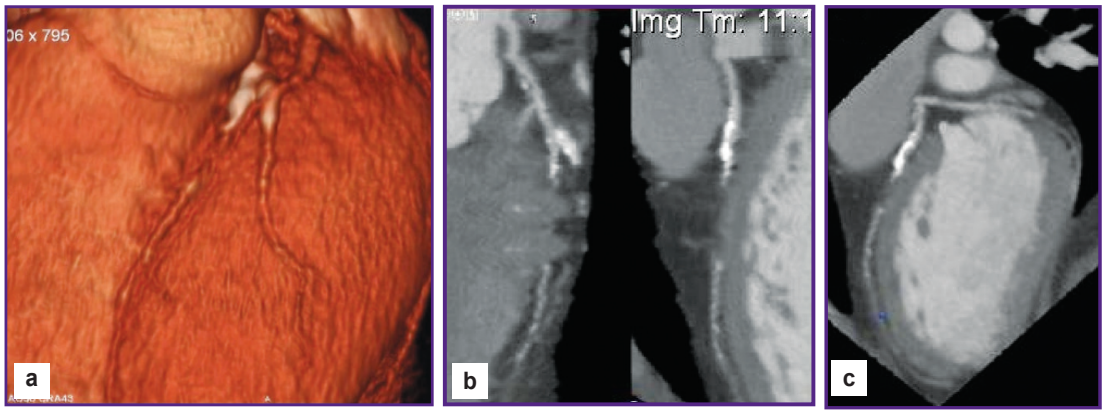

Figure 3. ECG-synchronized MSCT coronary angiography in high-resolution mode with slices of 128×0.25 mm in patients of group 2: occlusion of the anterior descending artery (ADA):
(a)–(c) image post-processing; the degree of occlusion, the length of the occluded segment, the contrasted distal sections of the occluded artery can be clearly seen as well as the presence of calcifications in the pre-occluded segment of ADA

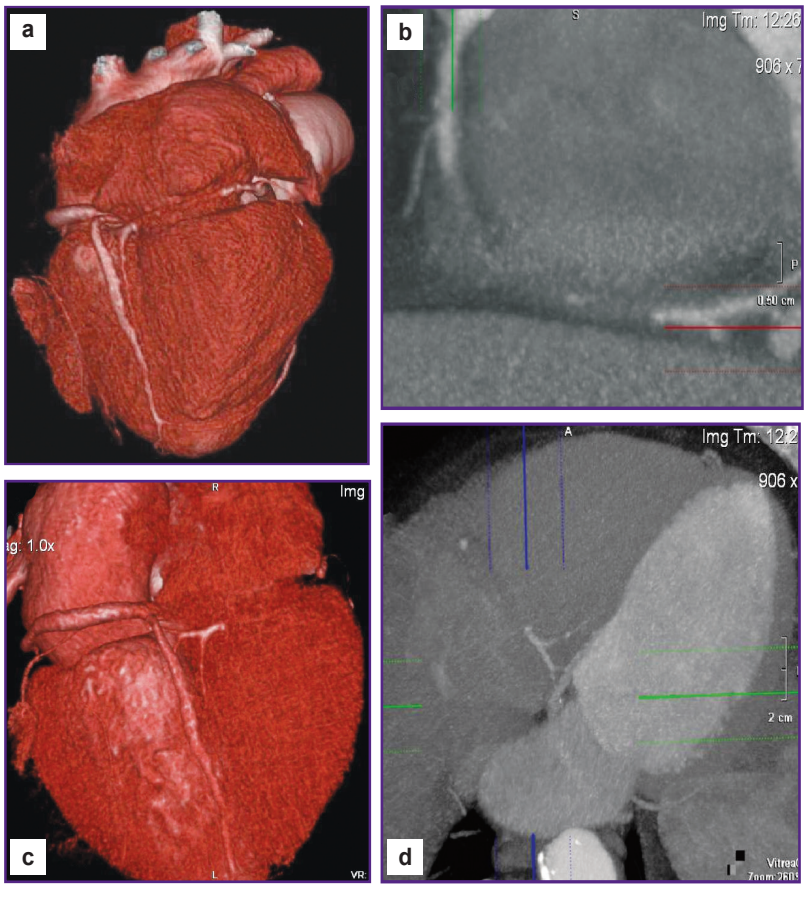

Figure 4. ECG-synchronized MSCT coronary angiography in high-resolution mode with slices of 128×0.25 mm in patients of group 3: occlusion of the right coronary artery (RCA):
(a)–(d) image post-processing; the degree of occlusion of RCA can be clearly seen as well as the length of the occluded segment (above 2 cm); no calcification or multi-segment occlusion is found; contrasting of the distal sections of the occluded RCA can be clearly seen

we decided on the treatment option — surgical or endovascular.

Twenty patients from group 1 were immediately referred to surgical correction of the coronary bed without attempting any endovascular intervention.

In group 2, all 27 patients underwent endovascular recanalization of the occluded segment: in 26 patients (97%) the intervention was successful, with a good angiographic result; in one case, the attempt was unsuccessful due to misinterpretation of the multi-segment structure and tortuosity of the occlusion.

All 9 patients of group 3 underwent endovascular

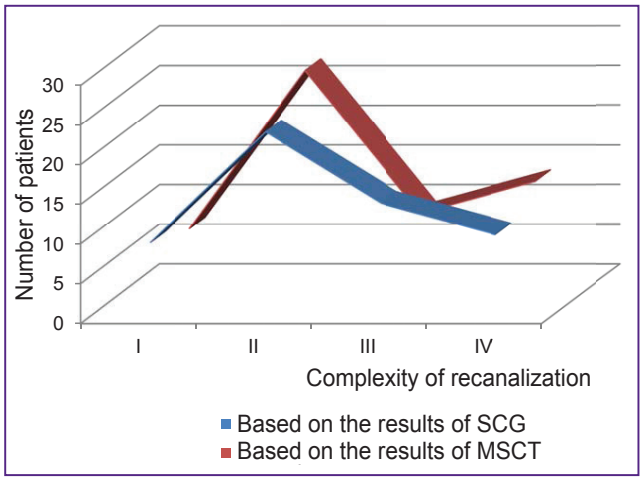

Figure 5. Patient distribution by the expected complexity of recanalization based on either the selective coronary angiography (SCG) and MSCT data

recanalization: in two patients the procedure was successful, and in seven patients the attempt was unsuccessful.

The main factors of failure were (i) the inability to pass a guidewire through a plaque to the distal coronary artery via the natural artery lumen due to massive calcification (3 patients), (ii) the multi-segment occlusions (3 patients), and (iii) the length of the occlusion above 2 cm (1 patient). In all these cases, the intervention was discontinued due to a high risk of artery wall perforation.

The proposed pre-selected treatment tactics (based on the MSCT and SCG data) was abandoned or modified in 15 patients (27%).

Thus, according to our experience, the combination of prognostic abilities of these two imaging methods resulted in an additional 10% of successful recanalizations in patients with chronic coronary occlusions.

Conclusion

The MSCT coronary angiography proved to be highly informative in assessing the parameters of coronary artery occlusions. For a number of parameters (the degree of calcification, the length and the multi-segment character of occlusion), the diagnostic value of MSCT is superior to that of the regular invasive SCG.

MSCT coronary angiography can serve an independent non-invasive diagnostic method in patients with occlusive coronary lesions and should be included in the algorithm for examining the patients scheduled for endovascular recanalization.

In a number of cases, the results of MSCT coronary angiography can be decisive in choosing the method of treatment in patients with chronic coronary occlusions.

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Conflict of interest. The authors confirm the lack of financial and other conflicting interests that could influence their work.

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