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SUPER RESOLUTION DEEP LEARNING RECONSTRUCTION: BENEFITS OF CONTRAST REDUCTION IN CARDIAC TOMOGRAPHY ANGIOGRAPHY, COMBINING THE POWER OF ARTIFICIAL INTELLIGENCE

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Abstract: Nowadays, iodinated contrast represents the most common drug administered to patients. A wide range of radiological examinations benefit from the opacification and enhancement characteristics of iodine. Recently, the lack of MCI was observed worldwide, resulting in a problematic scenario for health services. Due to this scarcity, several scientific works have been published discussing means and ways to reduce and save contrast. In the cardiological setting, coronary artery CT angiography (CTA) represents a well-established diagnostic method in non-invasive coronary assessment and its indications are increasing. Recently, a Super-Resolution Deep Learning reconstruction algorithm (SR-DLR) trained using data acquired on an Ultra High-Resolution Tomography (UHRTC) system was introduced worldwide in the clinical setting. It has the potential to accurately diagnose arteries and stent structures by combining exceptional spatial resolution, noise reduction and increased high contrast resolution, which can benefit the use of smaller volumes of iodine. The objective of this work was to evaluate the cardiac image with the PIQE Deep Learning reconstruction algorithm, using smaller volumes of iodinated contrast. CTA was performed on a 320-channel tomograph with 640 slices. Cardiac acquisition used prospective volumetric acquisition with cardiac synchronization through ECG monitoring, in addition to 100 KVp and non-ionic contrast (370mg/ml), with a flow of 5 mL/s. Results: In cases of ATC performed, a reduction greater than 35% was possible compared to the standard used by the institution. The use of PIQE with smaller MCI volume improved image resolution when compared to hybrid iterative reconstruction. The physical properties present in the PIQE algorithm, such as noise reduction and greater high-contrast resolution, resulted in excellent opacification of iodinated contrast in the evaluated exams.

Keywords: CT angiography; coronary arteries; contrast; iodine

INTRODUCTION

Nowadays, iodinated contrast represents the most common drug administered to patients. A wide range of radiological examinations benefit from the opacification and enhancement characteristics of iodine. Additionally, the number of iodinated contrast imaging (ICM) diagnostic tests continues to increase.[1]. It is estimated that around the world, one hundred million doses are administered annually[2].

Although the benefits of using iodine are established, there are absolute and relative contraindications to its administration. For patients with relative contraindications, a smaller injection volume can bring significant benefits and contribute to the clinical appearance of these patients[3].

Recently, the lack of MCI was observed worldwide, resulting in a problematic scenario for health services. Due to this scarcity, several scientific works have been published discussing means and ways to reduce and save contrast. [4,5,6]. This way, the shortage of MCI brings challenges to diagnostic centers around the world, but also offers an opportunity to reconsider how it is used, as this shortage was not experienced for the first time and possibly will not be the last.[7].

Computed Tomography (CT) plays an important role in the development of clinical and care activities, complementing or confirming diagnostic findings. In the cardiological setting, coronary artery CT angiography (CTA) represents a well-established diagnostic method in non-invasive coronary assessment and its indications are increasing. Since the beginning of the use of this method, much progress has been made in terms of hardware development and reconstruction for image quality, reduction of radiation dose and

MCI volume. Technologies that use artificial intelligence have been allowing exams with increasingly higher quality and with lower contrast volume[8].

Recently, a Super-Resolution Deep Learning reconstruction algorithm (SR-DLR) trained using data acquired on an Ultra High-Resolution Tomography (UHRTC) system was introduced worldwide in the clinical setting. PIQE (Precise IQ Engine) was trained on a 3D neural network that does not only learn features in the axial plane, but in 3 dimensions, which means that signal characteristics are identified and preserved in all 3 planes. It has the potential to accurately diagnose arteries and stent structures by combining exceptional spatial resolution, noise reduction and increased high contrast resolution, which can benefit the use of smaller volumes of iodine.

The objective of this work was to evaluate the cardiac image with the PIQE Deep Learning reconstruction algorithm, using smaller volumes of iodinated contrast.

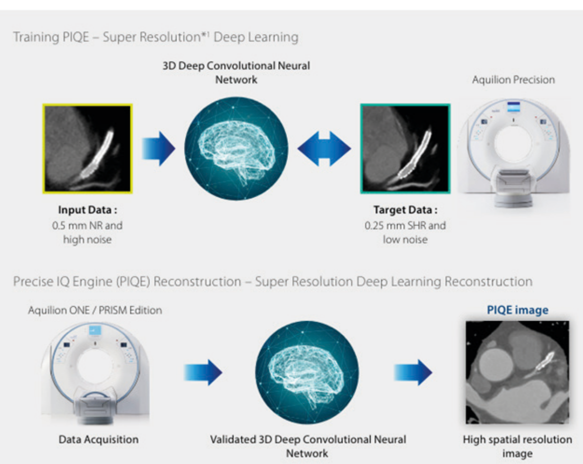

Figure 1: PIQE neural network training.

ACQUISITION PROTOCOL

CTA was performed on a 320-channel tomograph with 640 slices and the PURE Vision Optics detector (Aquilion ONE PRISM / Edition – Canon, Otawara, Japan). Cardiac acquisition used the following parameters: prospective volumetric acquisition with cardiac synchronism through ECG monitoring, with a 512x512 matrix, FOV of 200 – 240 mm, slice thickness of 0.5 mm, tube rotation of 0.275 seconds and modulation of dose. Furthermore, the energy used was 100 KVp and non-ionic contrast (370mg/ml), with a flow of 5 mL/s. The institution uses 70 ml to 80 ml of iodinated contrast as a standard when carrying out its CTA's. Therefore, in the tests performed, MCI was injected with a reduction of at least 30% of the usual volume.

CARDIAC CT ANGIOGRAPHY AND PIQE

PIQE is a super-resolution reconstruction algorithm that provides extraordinary spatial resolution and noise reduction, with acquisition requiring only one rotation of the x-ray tube for confident diagnosis of small cardiac vessels, plaques, stents and thin cardiac structures.

In cases of ATC performed, a reduction greater than 35% was possible compared to the standard used by the institution.

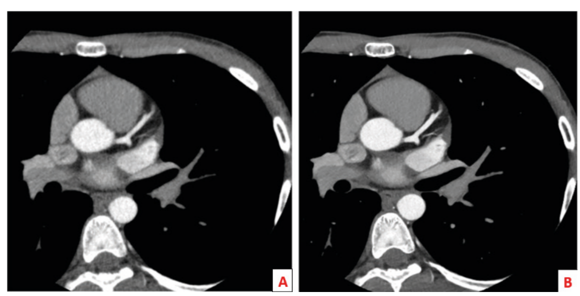

Figure 2: Axial Cardiac Tomography Angiogram Images, with a 42% reduction in the volume of iodinated contrast injected (Standard volume 70 ml; Injected volume 40ml). Image A displays the iterative reconstruction algorithm, while image B displays the Deep Learning reconstruction with PIQE.

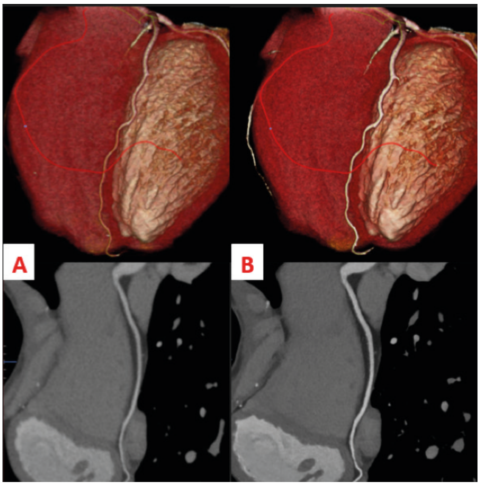

Figure 3: Exam with 42% reduction in iodine volume. Anterior Descending Coronary. Image A demonstrates weak opacification in both the 2D image and the 3D image using iterative reconstruction. Image B with PIQE shows better opacification and delineation of the cardiac vessels, in addition to less noise.

The use of PIQE with smaller MCI volume improved image resolution when compared to hybrid iterative reconstruction. The cardiac images analyzed had relevant calcifications and even occlusion of cardiac vessels. All these features were easily analyzed in the image using the Deep Learning reconstructor.

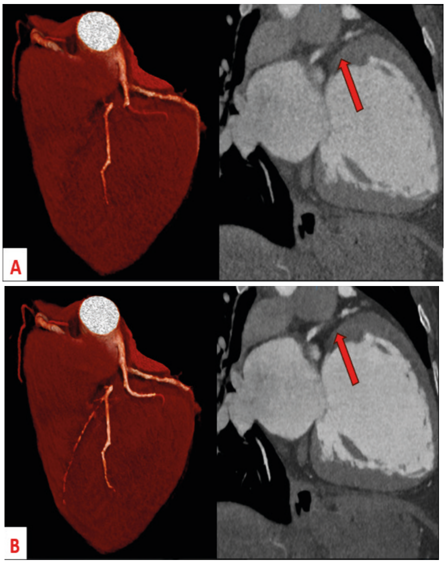

Figure 4: Cardiac image shows occlusion of the Anterior Descending Coronary. 50 ml of iodinated contrast were injected, representing a 37% reduction compared to the standard injection (80 ml) for this BMI. Image B has less noise, in addition to better characterization of other cardiac vessels.

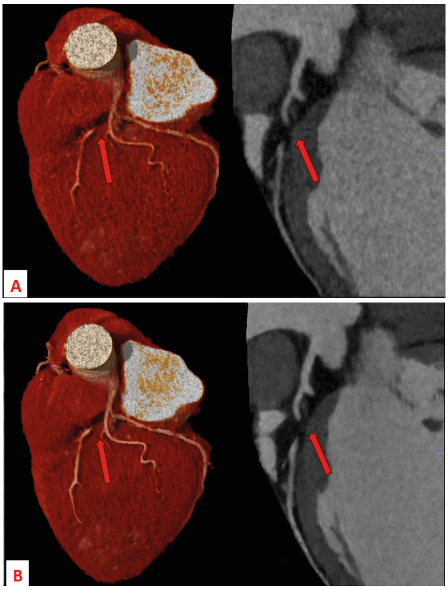

Figure 5: Image of the anterior descending coronary artery stretched, showing occlusion in the proximal region of the vessel. Figure B, reconstructed with PIQE, shows better contour, noise level and contrast opacification in the region.

CONCLUSION

The physical properties present in the PIQE algorithm, such as noise reduction and greater high-contrast resolution, resulted in excellent opacification of iodinated contrast in the evaluated exams. This excellent opacification and lower volume used contributed to the patients' physiological functions, in addition to resulting in optimization of the MCI and lower costs for the institution.

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