Journal of Cardiovascular Computed Tomography 13 (2019) 299–300

Contents lists available at ScienceDirect

Journal of Cardiovascular Computed Tomography

journal homepage: www.elsevier.com/locate/jcct

Correspondence: Submillisievert CT angiography for carotid arteries using wide array CT scanner and latest iterative reconstruction algorithm in comparison with previous generations technologies: Feasibility and diagnostic accuracy

The article by Annoni et al. reports the diagnostic accuracy of submillisievert CT angiography for the evaluation of carotid artery stenosis. In this study, the radiation dose reduction to submillisievert levels was achieved by decreasing kVp from 100 to 80 while minimizing the concomitant increase in noise through more advanced interactive reconstruction (ASIR-V). Annoni et al. prospectively used this low-dose protocol for carotid CT angiographic imaging in 105 patients referred for known carotid atherosclerosis or with suspected stenosis. Diagnostic accuracy was determined in a subset of patients who also underwent digital subtraction arteriography. The noise, signal to noise, contrast to noise, and radiation dose were determined and compared to a retrospective group of patients who underwent carotid CT angiography utilizing a higher-dose protocol of 100 kVp and earlier generation iterative reconstruction (ASIR). Annoni et al. showed that CT angiography of the carotid arteries using lower kVp and more advanced reconstruction can produce diagnostic quality imaging at a dose reduction up to 86%.

Since the 1970s, there has been a rapid increase in the use of CT imaging along with the associated exposure of radiation to the public, which may account for increased risk of cancers in the United States.[1] The total number of CT studies increased from 3 million in 1980 to 60–70 million in 2005.[2,3] In addition, the number of indications for more specialized CT examinations has also been expanding. The North American Symptomatic Carotid Endarterectomy Trial (NASCET) demonstrated that surgical treatment (endarterectomy) of carotid stenosis greater than 70% in symptomatic patients reduces the subsequent risk of stroke.[4] Consequently, non-invasive imaging of the carotid arteries for the purpose of determining stenosis is indicated for patients with carotid bruits, previous transient ischemic attacks, and ischemic stroke, and the noninvasive assessment for stenosis can be achieved by ultrasound, CT angiography, and MR angiography.[5] In contrast to ultrasonography, CT angiography can determine intracranial arterial stenosis, tandem stenosis, and aortic arch disease and avoids the high interobserver and intermachine variability associated with sonography.[6,7] In light of the rising use of CT imaging in various clinical applications such as carotid evaluation, CT dose reduction is of paramount importance to these patient populations.

The primary ways to reduce radiation dose in CT imaging is to decrease the current-time product (mAs) and peak kilovoltage setting (kVp) and to increase pitch.[2] The radiation dose is inversely proportional to pitch and directly proportional to the current time product and kVp squared or to the third power.[8,9] Just reducing the tube voltage alone from 100 to 80 kVp can by itself reduce the dose by 40% or greater. Automated exposure control dynamically reduces the current based on the attenuation derived from the initial topograms resulting in significant reductions in the mean dose for chest and abdominal CT studies.[10] The current can also be reduced by decreasing the tube current parameter or the exposure time.[9] The kVp parameter can also be adjusted as modifiable parameter, which should be in a range to exploit iodine's K-edge of 33 keV for enhanced studies.[8] The lower boundary of clinically acceptable range of the current-time product and kVp are limited by potential worsening image quality because of increasing noise, photon starvation, and beam hardening artifacts as these parameters are reduced.[11]

The reduction of radiation dose can be further augmented through noise-reduction computational methods which would allow for lowering the kVp without sacrificing image quality. For coronary CT angiography, the mainstay nose reduction computational technique is iterative reconstruction (IR), which was shown to reduce the radiation dose by nearly 50% while maintaining clinically acceptable diagnostic accuracy.[12] The increased use of IR is a relatively new development as the computational power needed for IR was only recently attained. Conceptually, IR works by starting with an initial assumption of the image and improves on the assumption iteratively based on the computed projections.[13] The study by Annoni et al. utilized a complex propriety IR technique called adaptive statistical iterative reconstruction V (ASiR-V) provided by GE Healthcare (Waukesha, WI, USA), which can be viewed as a hybrid between a raw-domain based reconstruction and model-based iterative reconstruction.[14,15] Currently, there are exciting advancements in artificial intelligence and deep learning, both of which allows for advanced IR optimization, features learning, and higher level functions for the ultimate purpose of improving CT reconstruction.[16]

Several limitations of the study conducted by Annoni et al. should be noted. There were two patients in this study who underwent the lose dose protocol (kVp 80 with ASiR-V reconstruction) for whom carotid stenosis was overestimated due to severe calcifications. Generally, this sort of overestimation may be due to blooming artifacts and volume averaging.[17] This is a widely known limitation that is encountered in clinical practice as well as demonstrated in the literature.[18,19] A subset analysis of patients with severe carotid calcification would be very useful in determining whether the low-dose protocol would yield diagnostic quality carotid imaging for the most challenging cases. Another limitation is that the ASiR-V algorithm is proprietary and not available for all imaging systems. Other vendors such as Siemens (Erlangen, Germany) and Phillips (Cleveland, OH) have their own proprietary IR algorithms.

Despite these limitations, the study by Annoni et al. provided

https://doi.org/10.1016/j.jcct.2019.03.003
Received 5 March 2019; Accepted 10 March 2019
Available online 30 March 2019
1934-5925/

important clinical evidence that good quality CT angiographic imaging can be accomplished at low radiation doses for the evaluation of the carotid arterial system just as it has been for the coronary arteries.

Conflicts of interest

None.

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