Original Research Article

Dose reduction strategy in CT renal and peripheral angiogram – Our experience

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Abstract

Objective: Computed tomography angiography has become a standard imaging tool for evaluation of vascular structures. However there is risk of increasing radiation exposures to the patients. The objective of our study is to perform computed tomography renal and peripheral angiograms by lowering tube current and resultant decrease in the effective radiation dose. **Materials and Methods:** A prospective study of computed tomography renal and peripheral angiogram was done in 135 patient s using 80 and 120 kilo voltage (kV). The post procedure effective radiation dose was noted and image quality was assessed. **Results:** Our study revealed significant reduction in effective radiation dose received by patient in whom angiogram was performed with low tube current. There was increase in the noise of the images, however radiologists had no difficulty in interpretation. **Conclusion:** Lowering tube current in angiogram is a robust method for reducing the radiation dose received by patients without significant compromise on image quality.

Key Words: Low Tube Current; Radiation Dose; CT Angiogram; Image Quality.

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INTRODUCTION

Computed tomography Angiography (CTA) has become a standard imaging tool for the evaluation of main vascular structures and it is a minimally invasive technique. Multi-Detector Computed Tomography (MDCT) has been used more frequently because of image acquisition speed, more coverage and high spatial resolution. However patients undergoing CTA are at risk of increased radiation exposure. Therefore CT protocols should be properly designed and carefully applied in order to obtain more information by using the lowest radiation achievable. Although there are several technological advances made for reduction of radiation dose, changing the basic parameters of scan, such as tube current and tube potential remain the most important means of dose optimization[1]. Tube current is a simple and straight forward way of radiation dose adjustment based on body region, clinical indication, and patient size or age. Reduction in tube current, for example: reduces radiation dose linearly but it decreases the image quality by increasing noise. Modern Multi -Detector Computed Tomography scanners now allow use of lower tube potential and iterative reconstruction technologies that help to cut the image noise while retaining enhanced contrast at lower tube potential. Low kV (kilovoltage) results in radiation dose reduction[2]. To better represent the overall energy delivered by a given scan protocol, the Computed tomography dose index – volume (CTDIvol) can be integrated along the scan length to compute the dose length product (DLP), where the DLP (in mGy-cm) is equal to $CTDI_{vol}$ (in mGy) times scan length (in cm). The DLP reflects the integrated radiation output (and thus the potential biological effect) attributable to the complete scan acquisition. Though the effective dose (E), is not a measurement of radiation dose, It is a concept that reflects the stochastic risk (e.g. cancer induction) from an exposure to radiation. It is typically expressed in the units of mSv. Effective dose reflects radiation detriment average over gender and age and it's used as several limitations when applied to medical population. While dose levels to occupationally exposed medical and paramedical individuals are limited to levels

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recommended by consensus organizations, limits are not set for medically – necessary exams or procedures[3]. Our objective in this study is to evaluate dose reduction strategy in CT Renal and Peripheral angiogram by lowering the tube current (kV) and to calculate the effective radiation dose delivered for all patient's in our study. Also to evaluate the image quality for subsequent implementation of low tube current (kV) in CT Renal and Peripheral angiogram.

MATERIALS AND METHODS

In a prospective study for 3 months after obtaining ethical clearance, hundred and thirty five patients were included in our study who came for CT renal and peripheral angiograms. Prospective renal donors and patients with peripheral vascular disease were included in our study. Those with impaired renal function were not included in our study. These patients were randomly divided in to two groups after checking the renal functions with both groups comprising of renal and peripheral angiograms. All these CT angiograms were performed in GE Light speed VCT 64 slice CT scanner. Low osmolar contrast agent (Iohexol) was used as a contrast agent and injected using dual head pressure injector with a dose of 1.2ml per kilogram. The scanning protocol for two groups included dual scout images at perpendicular angles, helical scan type with 5mm acquisition and 0.625mm reconstruction and detector coverage of 40mm. The pitch factor for renal angiogram was 1.375: 1 and for peripheral angiogram was 0.516:1. Both groups had different kilovoltage where one group underwent scans with 80 Kilo voltage and other group at 120 kilo voltage. The milliampere (mA) was stable for both groups with 650mA for renal angiograms and 735mA for peripheral angiograms. Image reconstruction from the acquired image data was performed with the following parameters: effective slice thickness of 0.625mm (retrospective-reconstruction). The data-sets were transferred to a workstation. Post-processing of the images namely Multiplanar Reformation (MPR), curved MPR, Maximum Intensity Projection (MIP) and Volume Rendering (VR) were performed. The effective radiation dose (mSv) evaluation was based on DLP dose index using the conversion co-efficient for renal angiogram (k-factor, k=0.015) and for peripheral angiogram [120kV (male k=0.0060, female k=0.0073), 80kV (male k=0.0046, female k=0.0057)]. At the end of every acquisition DLP dose value calculated by CT scan software and displayed on the display monitor. The effective radiation dose was evaluated for all these studies performed at 120kV and 80kV.

RESULTS

Out of 135 patients, 79 were males and 56 were females. 75 patients underwent renal angiograms and 60 underwent peripheral angiograms. All CT angiogram were completed with no reported complications or related adverse contrast reaction to the patients, who underwent the examination. All data sets with post processing images are provided for the radiologist interpretation. The mean effective dose value of renal angiogram was 41.67mSv with a maximum value of 54.77mSv and minimum value of 30.60mSv using the standard dose scan protocol (120kV).It was 14.66mSv with a maximum value of 17.85mSv and a minimum value of 13.37mSv using the modified dose scan protocol of (80kV). (Figure 1) The mean effective dose value of peripheral angiogram was 32.5mSv with a maximum value of 40.17mSv and a minimum value of 28.33mSv using the standard dose scan protocol (120kV). It was 7.376mSv with a maximum value of 8.86mSv and a minimum value of 6.39mSv using the modified dose scan protocol of (80kV).(Figure 2) In renal angiogram, the dose was reduced by a factor of 35% approximately and in peripheral angiogram, it was reduced by a factor of 23% approximately while using 80 kV as tube current. The image quality at low tube voltage had more noise, however no significant changes were seen in post processing and reporting of scans by radiologists.(Figure 3 and 4).

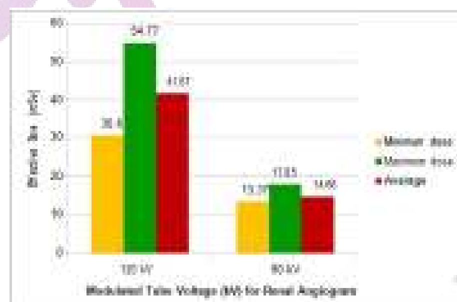

Figure 1: Graphical analysis of minimum, maximum and average dose obtained in CT renal angiogram at tube currents of 120 kV and 80kV

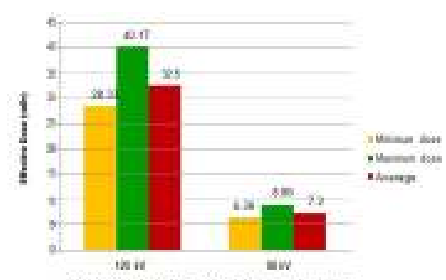

Figure 2: Graphical analysis of minimum, maximum and average dose obtained in CT peripheral angiogram at tube currents of 120 kV and 80kV.

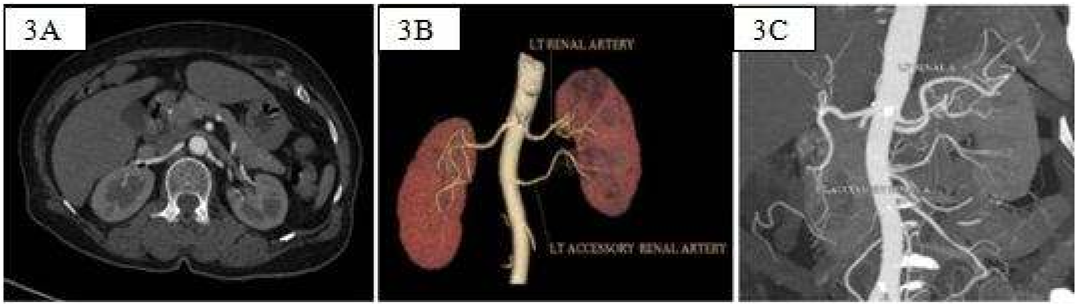

Figure 3: CT renal angiogram done in 120 kV with axial source image (3A), Volume rendered image (3B) and Maximum intensity projection in coronal view (3C).

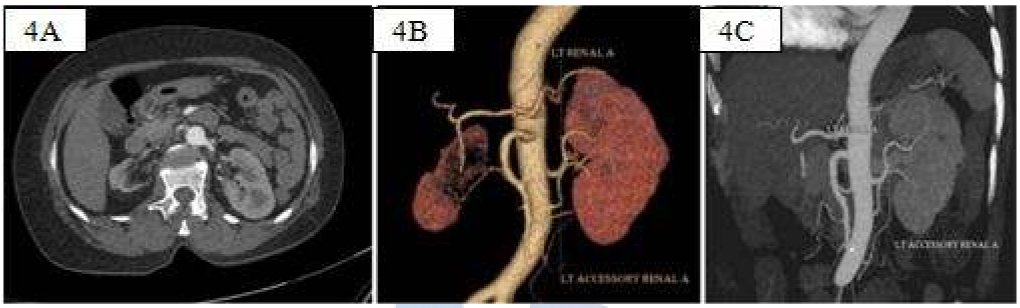

Figure 4: CT renal angiogram done in 80 kV with axial source image (4A), Volume rendered image (4B) and Maximum intensity projection in coronal view (4C)

DISCUSSION

Radiation dose reduction is one of the principal focus of CT protocol optimization. Considering the substantial and repeated usage of CT in diagnostic imaging and the improving scanner performance, care should be taken to keep the radiation dose as minimum as possible with no compromise in image quality leading to reporting of the scans. Radiation output is proportional to the square of the x-ray tube voltage, such that even smaller decrements in the tube voltage will result in substantial reductions in radiation dose. A lower tube potential results in low average energy and lower photon flux thus, lower radiation dose delivered. Reducing the tube voltage from 120 kV to 100 kV results in a 33% dose reduction, whereas reducing the tube voltage from 120 kV to 80 kV yields a 65% dose reduction at a constant tube current[4]. Unlike the tube voltage, the tube current has a linear relationship with the radiation dose which will note help in reducing the radiation dose. Considering various strategies for reducing CT radiation dose, modifying the tube current in renal angiogram and peripheral angiogram were implemented in our study and acquired images were evaluated for its quality and resolution. In our study, Reducing the tube current resulted in a significant dose reduction. CT angiogram at a low kilovoltage setting (80kVp) is beneficial enabling better visualization of contrast enhanced vascular structures. X-rays generated at 80kV tube potential have significant less mean energy compared to x-rays generated at 120kV tube potential. The vessel visualization remains the same with the same amount of contrast administration but at a lower radiation dose. In renal angiogram, the dose reduced by a factor of 35% approximately and in peripheral angiogram, it was reduced by a factor of 23% approximately. In a similar study done by Erica Maffei, The dose were reduced by 50% while using 80Kv as tube potential. Radiation dose reduction should be achieved without compromising image quality. The change in the image noise is approximately inversely proportional to the change in the tube voltage. Thus, lowering the tube voltage will increase image noise and may decrease image quality[1]. In our study, the low dose scan protocol (80kV) has provided images with increase intravascular signal but with an associated increase in the image noise which was unavoidable. However the image noise in CTA was not a challenging issue for the radiologist in image interpretation. Also, Use of iterative reconstruction markedly reduces the image noise without sacrificing spatial resolution. It uses a correction loop in the reconstruction of an image from the raw image data. This significantly reduces image noise and provides high-contrast CT image performed with low tube voltage, affording radiation dose reduction without deteriorating image quality. Moreover the most significant results were obtained in terms of dose reduction.

CONCLUSION

Low tube voltage imaging is a robust method for radiation dose reduction in CT examinations and our study reveals the feasibility of low kilovoltage protocol

(80kV) for CT Renal angiogram and CT Peripheral angiogram compared to the CT angiogram performed at 120kV, thus reducing the radiation dose with no significant compromise in image quality.

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