Khamis AK et al., J Diagn Tech Biomed Anal 2020, 9:3

Journal of Diagnostic Techniques and Biomedical Analysis

Research Article

A SCITECHNOL JOURNAL

Assessment of Low Versus Standard kVp Settings in Cerebral CT Angiography for the Optimization of Contrast Medium

Atef K. Khamis[1], Mohamed M. El-Safwany[1], Samir M. Abdel-Mageed[2] and Ehab I. Mohamed[3]

Abstract

Recent advances in Computed Tomography (CT) have greatly increased the clinical applications of CT, especially since the advent of Multi-Detectors Row CT (MDCT) technology. CT Angiography (CTA) has been advocated for pre-operative evaluation of cerebral blood vessels pathologies and their relationship with the main branches. Moreover, it is crucial to detect other vascular morbidities, such as arterial occlusive diseases. CTA allows the proper visualization of main vascular structures and has several advantages: minimal invasiveness, with a lower complication rate than that of angiography; generation of high spatial resolution images; availability of multi planar reconstructions and 3D reconstructions; and short examination time, allowing extended scan ranges.

Consequently, potential benefits of lower-kV scanning at contrast-enhanced CT include reduced radiation dose with similar contrast-to-noise ratio and reduced effective dose. Recently, lower-kV imaging has been shown to result in improved conspicuity of cerebral blood vessels lesions and dominancy in different patients. In addition to the radiation dose savings, lower-kV scanning may be beneficial, for diagnostic purposes in patients with poor i.e., access or renal impairment in whom a smaller contrast dose or slower infusion rate may be necessary or in patients in whom subtle attenuation differences may be diagnostically important.

Low-tube-voltage-setting protocol combined with low contrast agent volume, by using new MDCT scanners represents a feasible diagnostic tool to significantly reduce the radiation dose delivered to patients and to preserve renal function, while also maintaining adequate diagnostic quality images. Since the introduction of MDCT, CTA has become a standard imaging tool for the evaluation of diseases affecting the carotid arteries and their branches. Result of the present study was as follow: There was a higher significant difference in all study cases group when compared with the control group (2). The dose of contrast medium and radiation given to the patient to perform a MDCT scan on the cerebral vascular system by using the low kilovolt technology was reduced by 38% and 40%, respectively, while also maintaining adequate diagnostic quality images.

***Corresponding author:** Atef K Khamis, Department of Radiological Sciences and Medical Imaging Technology, Faculty of Applied Health Sciences Technology, Pharos University, Alexandria, Egypt, Tel: +201000922065; E-mail: atef.kamal@pua.edu.eg

Received: October 30, 2020 **Accepted:** November 13, 2020 **Published:** November 20, 2020

Keywords

Multi-detectors; Vascular morbidities; Angiography

Introduction

Computed Tomography (CT) uses X-ray equipment to create cross-sectional layers that show detailed images of the internal body organs, including bones, tissues, and tumors. During CT procedure, series of images are created like a loaf of sliced bread which can be looked at individually. These two dimensions (2D) sliced images can be combined to create three dimensions (3D) images. CT Images help doctors to diagnose various diseases especially involving cerebral blood vessels. CT images can show information which experienced radiologists can use to get approximate location of different cerebral blood vessels pathologies. Conventional CT scan takes series of images of slices of the body. These slices are few millimeters apart. Recent technical advances in CT scan increase the effectiveness and speed by taking continuous images of the body so that there is no gape in the images collected. CT scanning is associated with significantly higher radiation exposure compared with other radiation-based medical examinations, including conventional radiography and nuclear medicine studies. Because of this, there is a strong need to minimize the radiation dose according to the ALARA (As Low as Reasonably Achievable) principle.

Recent advancement of CT has markedly enhanced its clinical applications, and during the last few decades, there has been a remarkable increase in the use of CT. Many studies have documented the radiation doses that patients receive from medical imaging, with particular attention devoted to CT. It is crucial to keep radiation doses as low as possible. Multi-Detector CT (MDCT) protocols can be optimized in a variety of ways to reduce the overall radiation dose, including individualization of acquisition protocols by decreasing the number of scanning phases, adjustment of the tube peak voltage (kVp setting) and tube current-time product (mill ampere-seconds, mAs), or use of noise reduction filters. Adjustment of the tube peak voltage (kVp setting) is the most frequently used a method to reduce radiation dose, by adjusting tube current based on the size and attenuation characteristics of the body part being scanned.

Since the first application of CT Angiography (CTA) for the diagnosis of acute Pulmonary Embolism (PE) in the early nineties, CTA has become the first imaging technique of choice in the workup of patients with suspected vascularity pathologies. Though the considerable inherent limitations of CTA with Single-Detector CT (SDCT) systems, its diagnostic potential for direct visualization of arterial clots was instantaneously appreciated by the radiological community. Limited by a maximum breath hold of 30 s and a single detector row data acquisition, image quality and thus diagnostic efficiency was limited by the tradeoff between the need to cover a certain scan length and the spatial resolution determined by the slice collimation e.g., with a slice collimation of 5 mm only a scan range of 17 cm could be covered within 30 s. Even with use of 3 mm collimation and a pitch of 0.9, a confident detection of small vascularity pathologies was only possible within a small region of the brain. With the newest generation CT scanners the full brain can be scanned in less than 8s with sub-millimeter collimation which has become the standard nowadays.

Small thrombi can be identified in arterial sub-branches and elaborate post-processing techniques can be executed, resulting in a significant increase of both sensitivity and specificity in cerebral vascularity pathologies detection. This substantial gain in image acquisition speed and spatial resolution also lead to novel image interpretation concepts including the assessment of perfusion defects of the cerebral vascularity and the evaluation of cardiac dysfunction, both of which are important determinants for the clinical outcome of the patient. The development of faster CT scanning techniques has resulted in a substantial decrease of the percentage of non-interpretable scans (overall from 10% using SDCT techniques to up to 6% for MDCT.

CTA has been advocated for pre-operative evaluation of cerebral blood vessels aneurysms and their relationship with the main branches. Moreover, it is crucial to detect other vascular morbidities, such as arterial occlusive diseases. CTA allows the proper visualization of main vascular structures and has several advantages: minimal invasiveness, with a lower complication rate than that of angiography; generation of high spatial resolution images; availability of multi planar reconstructions and 3D reconstructions; and short examination time, allowing extended scan ranges. The extended use of MDCT in the clinical practice, however, may result in an increase of both the frequency of CTA studies and patient's radiation exposure compared with single-slice CT.

Consequently, potential benefits of lower-kV scanning at contrast-enhanced CT include reduced radiation dose with similar contrast-to-noise ratio and reduced effective dose. Recently, lower-kV imaging has been shown to result in improved conspicuity of cerebral blood vessels lesions and dominancy in different patients. In addition to the radiation dose savings, lower-kV scanning may be beneficial, for diagnostic purposes in patients with poor i.e., access or renal impairment in whom a smaller contrast dose or slower infusion rate may be necessary or in patients in whom subtle attenuation differences may be diagnostically important.

Materials and Methods

CT equipment

MDCT scanner model (Philips Brilliance 64 slice; Philips Medical Systems, Holland).

Patients study

The study comprised 25 patients , who were examined by cerebral MDCT angiography; using 80 and 140 kV techniques and then the statistics was calculated.

MDCT cerebral angiography technique

The study was performed following scan steps according to cerebral circulatory phases namely arterial, venous, and delayed phase if needed for patients suspected with arterial diseases of the head. All patients underwent CTA of the head. Contraindications for Head CTA included known prior reactions to iodinated contrast agents, severe renal impairment, severe cardiac insufficiency, and pregnancy. Each patient's age and body weight were recorded prior to the CT examination.

Acquisition protocol

All head CTA examinations were performed using a Philips Brilliance 64 slice; Philips Medical Systems, Holland. Patients were positioned supine on the CT table with both arms along the chest. The CM iodixanol (370 mg of iodine per milliliter, Ultravist, Bayer-Schering HealthCare, Germany) was injected intravenously through a 18 gauge needle, into the antecubital vein by using a high-power auto injector (SDS-CTP-QFT Medrad Stellant CT Dual Head High Pressure Injectors Syringes).

Patients were randomly assigned to one of the 80-kVp (group A) or 140-kVp (group B) protocols. In group A, patients received 65 mL CM with a flow rate of 5 mL/s followed by 50 mL saline solution with the same flow rate. In group B, patients received 100 mL CM and 50 mL saline solution with a flow rate of 5 mL/s.

CT acquisition was triggered by using a bolus tracking technique with the Region of Interest (ROI) sized 0.05 sq placed in the ascending aorta. For both the 80 and 140 kVp protocols, image acquisition was started 3 seconds after attenuation reached the predefined threshold of 110 HU, pitch 0.55, gantry rotation time of 0.4 s/rotation, slice thickness 0.9 mm and caudocranial scan direction for the arterial phase and craniocaudal for the venous phase.

Image reconstruction

CT images at 80 and 140 kVp groups were reconstructed using a standard (B) filter algorithm (H 20 s smooth kernel). All image series were reconstructed with a 0.6 mm section thickness and 0.45-mm increment and thus 0.75 mm pitch. Each image dataset was coded and randomized to enable double-blinded evaluation, also with anonymized patients' information. All images were transferred to a dedicated workstation (Extended brilliance Workspace R 4.5). Multi Planar Reformation (MPR) and Maximum Intensity Projections (MIP) images were reconstructed.

Determination of Image Quality was Assessed

Quantitative analysis includes

All quantitative analysis was performed on the workstation of computed tomography machine (Philips Brilliance 64 slice; Philips Medical Systems, Holland). The images sets were displayed side by side with a preset soft tissue window (WW, 360 HU; WL, 60 HU) (162, 163). For all measurements, the size, shape, and position of the ROIs were kept constant by applying the copy-and-paste function at the workstation. The size of the ROIs was (0.05 sq cm). CT attenuation, standard deviation (SD), Signal-to-Noise Ratio (SNR), and Contrast-to-Noise Ratio (CNR) were calculated, and mean value of three measurements on the same vessel was calculated:

After injecting the contrast material, in the brain region, the ROI was placed on the right middle cerebral artery segment 1 for the evaluation of 1-CT attenuation of the right middle cerebral artery segment 1 rMCA, 2-SDrMCA, 3-CT attenuationBA, 4-and SDBA.

To assess the mean signal intensity, the attenuation values in the ROI using a circular tool were measured. The ROI was drawn large enough to include as much of the contrast-filled vessel and to avoid vessel wall or small calcification. To avoid partial volume effects, severe calcification or very thin parts of the arteries were avoided, and occluded vessels were excluded. SNR and CNR were calculated for each region by the following formulas:

SNR=CT attenuationa / SDa

CNR = (CT attenuationa – CT attenuation$_m$)/SD$_m$

Where CT attenuationa and SD$_a$ indicated the mean HU and noise of target arteries.

CT attenuationm and SD$_m$ indicated the mean HU and noise of surrounding muscles on the same level of target arteries.

The mean CT attenuation value (Hounsfield unit) (HU)

The values for The mean CT attenuation values for segment one of right middle cerebral artery and its background in low and standard kV techniques were manually calculated by CT control console of CT machine by applying a circle on the blood vessel and its background and measured in HU as shown in Figure 1.

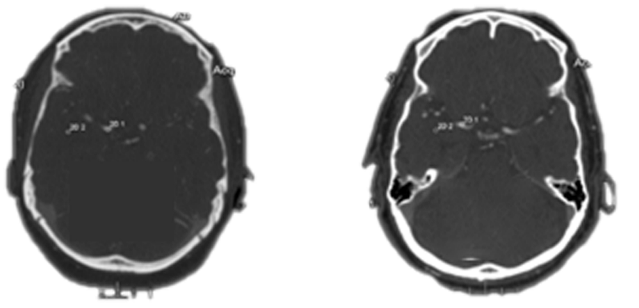


Figure 1: The calculated HU for right middle cerebral artery of the brain and its background at arterial phase image (a) for 80 kVp technique, and at arterial phase image (b) for 140 kVp technique.

Signal-to-Noise Ratio (SNR) for enhanced blood vessel

The SNR values for the enhanced cerebral blood vessel images were calculated by divided the mean attenuation value of the enhanced cerebral blood vessel ROI$_1$ by the SD$_1$ of image noise for the ROI$_1$ in the enhanced cerebral blood vessel as shown in Figure 2. SNR calculated by Equation 1.

$$\ddot{u} \qquad \frac{\ddot{u}}{\ddot{u}}$$

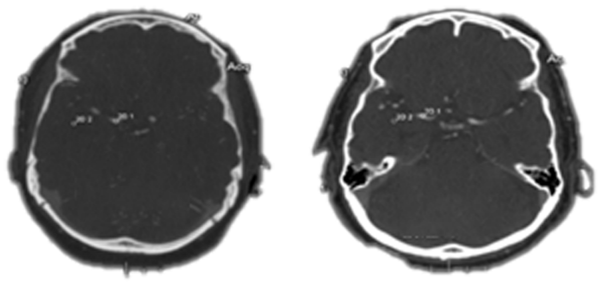


Figure 2: The calculated SNR for the enhanced cerebral blood vessel at arterial phase image (a) in the bone window for 80 kVp technique image and at arterial phase (b) for 120 kVp technique image.

$\mu_\circ$ is the mean gray value was expressed by ROI$_1$ and $\sigma_\circ$ is a standard deviation of the ROI's gray values which is the associated the noise in that region and it can be expressed by SD$_1$ (Figure 2).

Enhanced blood vessel SD of attenuation coefficient values

Objective image noise was measured for images as the blood vessel SD of the pixel values from a ROI$_o$ placed on a homogenous region of right middle cerebral artery of the brain at the arterial phase image in the bone window. The blood vessel SD is measured in HU (Figure 3).

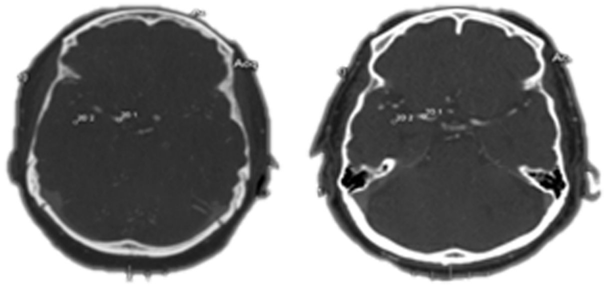


Figure 3: The calculated SD for right middle cerebral artery of the brain at arterial phase image (a) for 80 kVp technique, and at arterial phase image (b) for 140 kVp technique.

Contrast-to-Noise Ratio (CNR) for the enhanced blood vessel

CNR relative to the enhanced cerebral blood vessel as shown in Figures 3-5 it was calculated using the following Equation 2.

$$\ddot{u} \qquad \frac{\ddot{u}\ddot{u}\ddot{u}\ddot{u}_{\ddot{u}}}{\ddot{u}}$$

Where ROI$_1$ is the mean attenuation value of the enhanced cerebral blood vessel, ROI$_o$ is the mean attenuation value of background (unenhanced blood vessel) and SD$_o$ of image noise for the ROI$_o$ in the un enhanced blood vessel. The mean grey values of background μb was expressed by ROI$_o$ and object $\mu_\circ$ by ROI$_1$, the noise from the standard deviation σb of the pixel grey values in that region can be expressed by SD$_o$ (Figure 4).

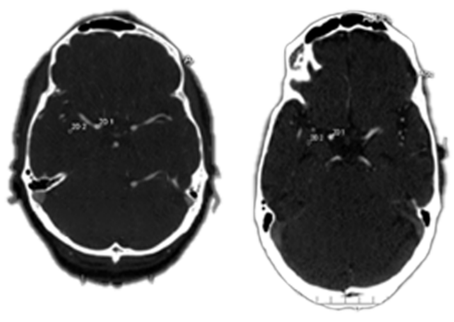


Figure 4: The calculated CNR for the enhanced cerebral blood vessel at arterial phase image (a) in the bone window for 80 kVp technique image and at arterial phase (b) for 140 kVp technique image.

Radiation dose estimation

With all protocols (80 and 140 kV protocols), the volume CT dose index ($CTDI_{vol}$, in milligray) and dose-length product (DLP, in milligray*centimeter) were recorded from the dose report for every CT examination. The effective dose (ED, in millisieverts) was calculated by multiplying DLP with a constant region-specific conversion coefficient of 0.0021 mSv/(mGy cm) for head CT imaging (Figure 5).

ED=DLP * k(constant).

Figure 5: The calculated of total DLP at arterial phase image (a) for 80 kVp technique and at arterial phase (b) for 140 kVp technique.

Results

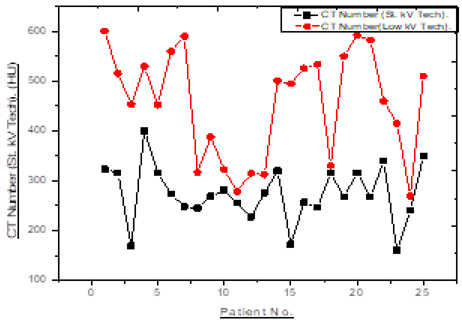
Determination of image quality

Quantitative analysis: All quantitative analysis was performed on the workstation of CT machine. The images sets were displayed side by side with a preset soft tissue window (WW, 360 HU; WL, 60 HU).

Quantitative analysis assessed by the mean CT attenuation value (Hounsfield unit) (HU): The mean CT attenuation values also showed a difference between protocols which use the low and standard kV techniques. The mean CT attenuation values in low kV technique ranged from 278.6 to 601 HU. While in standard kV ranged from 160 to 400.1 HU. The minimum values of the mean CT attenuation values in low and standard kV techniques were (278.6, 160 HU) and the maximum was (601, 400.1 HU) respectively. The mean CT attenuation values in the protocol using low kV technique were higher than the mean CT attenuation values in standard kV technique as demonstrated in Table 1 and Graph 1.

Table 1: The calculated CT Number values in standard and Low kV techniques for the enhanced cerebral blood vessels "patient No 1: 25".

Patient No.	***CT number (Low 80 kV tech) (HU)***	***CT number (Stand.140 kV tech) (HU)***
1	601	323.3
2	515	315.9
3	453.5	169.2
4	529.6	400.1
5	452.7	316.5
6	559.8	273.7
7	590.5	248.3
8	317.7	244.7
9	387.4	269
10	323.3	281.4
11	278.6	256.2
12	315.4	227.8
13	312.7	275.8
14	500.3	320.2
15	495.3	172.1
16	525.8	257.1
17	534.1	246
18	330.6	316
19	550	268.3
20	592.5	316
21	582.9	268.3
22	460	340
23	415	160
24	270	240
25	510	350



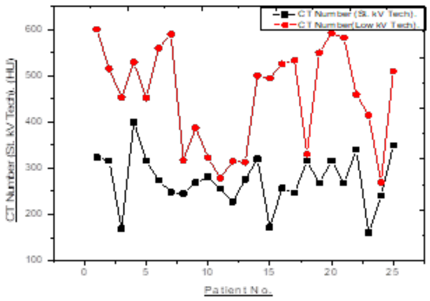
Graph 1: The calculated CT Number values in standard and Low kV techniques for the enhanced cerebral blood vessels "patient No 1: 25".

SD values of hounsfield unit of enhanced cerebral blood vessel: Compare the mean cerebral blood vessel SD attenuation of the Hounsfield unit related to image noise which was obtained for the region of the right middle cerebral artery with low and standard kV techniques. Cerebral blood vessel SD of image noise with low kV technique ranged from 18.8 to 95.8 HU while in standard kV technique the cerebral blood vessel SD of image noise ranged from 6 to 40.7 HU at the region of the right middle cerebral artery (Table 2 and Graph 2).

Table 2: The calculated cerebral blood vessel SD of image noise in standard and Low kV techniques "patient No 1: 25".

Patient No.	***Cerebral blood vessel SD "Low 80 kV tech" HU***	***Cerebral blood vessel SD "Stand 140 kV tech" HU***
1	44.7	27.6
2	95.8	23.5
3	70.5	11.6
4	75.1	27.3
5	60.8	21.2
6	52.3	18.4
7	18.8	38.1
8	42.9	15.6
9	35.5	16.3
10	27.6	6.8
11	23.8	29.8
12	28.9	6
13	31.2	17
14	60.5	22.9
15	59.5	9.8
16	62.1	22.3
17	37.9	17.3
18	33.7	40.7
19	92.7	20.4
20	34.3	40.7

21	34.7	20.4
22	26	18
23	59	9.4
24	20.3	23.2
25	56	19.3

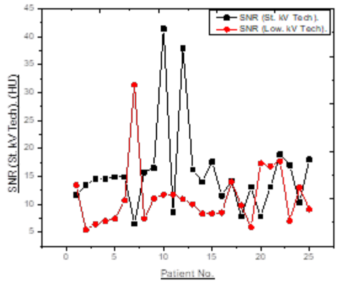


Graph 2: The calculated cerebral blood vessel SD of image noise in standard and Low kV techniques "patient No 1: 25".

SNR for enhanced blood vessel: The values of SNR for studies performed with low and standard kV techniques are summarized in the Table 3 and Graph 3. The values of SNR for enhanced cerebral blood vessel with low kV technique ranged from 5.4 to 31.4 HU while SNR for cerebral blood vessel with in standard kV technique ranged from 6.5 to 41.4 HU.

Table 3: The calculated SNR values of image in standard and Low kV techniques in the region of the right middle cerebral artery "patient No 1: 25".

Patient No.	*SNR (Low 80 kV tech) (HU)*	*SNR (St.140 kV tech) (HU)*
1	13.4	11.7
2	5.4	13.4
3	6.4	14.6
4	7	14.6
5	7.4	14.9
6	10.7	14.9
7	31.4	6.5
8	7.4	15.7
9	11	16.5
10	11.7	41.4
11	11.7	8.6
12	10.9	38
13	10	16.2
14	8.3	14
15	8.3	17.6
16	8.5	11.5
17	14	14.2
18	9.8	7.8
19	5.9	13.1
20	17.3	7.8
21	16.8	13.1
22	17.7	18.9
23	7	17
24	13	10.3
25	9.1	18

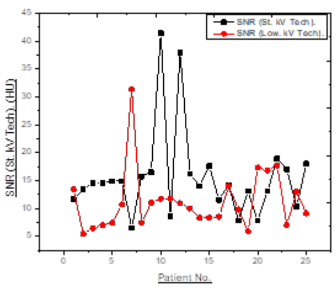


Graph 3: The calculated SNR values of image in standard and Low kV techniques in the region of the right middle cerebral artery. "patient No 1: 25".

CNR for enhanced blood vessel: The values of CNR for studies performed with low and standard kV techniques are summarized in the Table 4 and Graph 4. The values of CNR for enhanced cerebral blood vessels performed with low kV technique ranged from 27.7 to 102.7 HU. While CNR for cerebral blood vessels performed with standard kV Technique ranged from 22.4 to 72.8 HU.

Table 4: The calculated CNR of image in standard and Low kV Techniques in the region of the right middle cerebral artery "patient No 1: 25".

Patient No.	*CNR (Low 80 kV tech) (HU)*	*CNR (St.140 kV tech) (HU)*
1	71.4	38.6
2	46.9	22.4
3	62.3	33.6
4	102.7	62
5	27.7	25.5
6	76.3	44.7
7	32	31.6
8	44.4	40.4
9	57.4	22.5
10	38.6	35
11	53	30.5
12	49.6	34.8
13	52.5	48.2
14	50	37.9
15	36.5	24.7
16	42.3	39
17	41.6	20.3
18	54.6	25.6
19	55.1	33.5
20	69.4	54.6
21	55.1	50.8
22	81	72.8
23	80.1	38.5
24	57	32.3
25	47	45.7



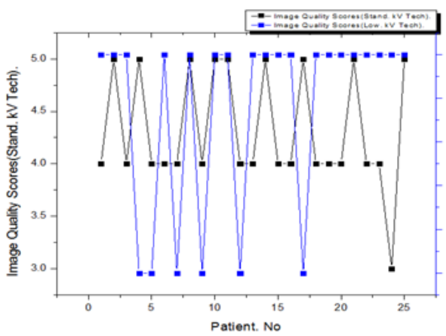
Graph 4: The calculated CNR of image in standard and Low kV Techniques in the region of the right middle cerebral artery. "patient No 1: 25".

Qualitative Analysis

Reader 1, qualitative evaluation (Table 5 and Graph 5).

Table 5: Grades of image quality scoring Reader 1 "patient No 1:25".

Patient No.	*Image quality "Score Low 80 kV tech"*	*Image quality " Score Stand 140 kV tech"*
1	5	4
2	5	5
3	5	4
4	4	5
5	4	4
6	5	4
7	4	4
8	5	5
9	4	4
10	5	5
11	5	5
12	4	4
13	5	4
14	5	5
15	5	4
16	5	4
17	4	5
18	5	4
19	5	4
20	5	4
21	5	5
22	5	4
23	5	4
24	5	3
25	5	5



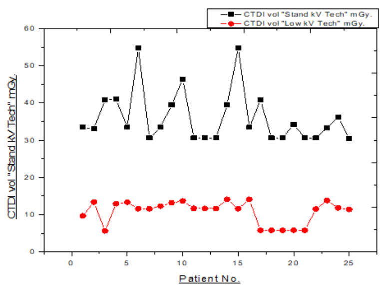
Graph 5: Reader 1 evaluation scores of image quality in standard and Low kV Techniques "patient No 1: 25".

Difference of radiation exposure outcome results

Computed Tomography Dose Index volume ($CTDI_{vol}$): The values for $CTDI_{vol}$ in Low and Standard kV techniques were automatically calculated by CT control console of CT machine and measured in mGy as shown in the Tables 3-6 The $CTDI_{vol}$ values also showed a difference between protocols which use of Low and Standard kV techniques. $CTDI_{vol}$ values in Low kV technique ranged from 5.80 to 14.13 mGy while in Standard kV ranged from 30.40 to 54.71 mGy. The minimum values of $CTDI_{vol}$ in Low and Standard kV techniques were (5.80, 30.40 mGy) and the maximum was (14.13, 54.71 mGy) respectively (Table 6 and Graph 6).

Table 6: The calculated CTDI vol in standard and Low kV techniques "patient No 1: 25".

Patient No.	*CTDI vol "Low 80 kV tech" mGy"*	*CTDI vol "Stand 140 kV tech" mGy*
1	9.7	33.47
2	13.38	33.13
3	5.62	40.8
4	12.96	41
5	13.35	33.47
6	11.61	54.71
7	11.61	30.59
8	12.3	33.47
9	13.2	39.5
10	13.7	46.37
11	11.7	30.59
12	11.65	30.68
13	11.66	30.59
14	14.13	39.5
15	11.6	54.71
16	14.13	33.47
17	5.8	40.8
18	5.8	30.59
19	5.8	30.68
20	5.8	34.22
21	5.8	30.68
22	11.55	30.59
23	13.8	33.3
24	11.83	36.2
25	11.4	30.4



Graph 6: The calculated CTDI vol in standard and Low kV techniques "patient No 1: 25".

Discussion

Multi-detector row CTA has been widely used to detect intracranial pathologies due to its high diagnostic accuracy and image quality. However, radiation exposure and contrast material-induced nephropathy caused by CTA have received extensive attention. Currently, technical progress such as high-pitch technology, tube voltage, and tube current reduction enable performing cerebral CTA with ever lower radiation dose and contrast media volumes while maintaining image quality.

This study, conducted in a patient population with randomization, demonstrates that a low tube voltage, low amount of contrast agent in cerebral CTA protocol shows a tremendous challenge to the standard protocol for detecting intracranial pathologies compared with a reference standard. Cerebral CTA with 80 kVp/65 mL of contrast media could reduce the effective radiation dose by approximately 40% and contrast agent volume by 38% without compromising diagnostic yield.

Our findings are in agreement with the results of previous investigations showing that lowering the tube voltage can reduce the effective dose without affecting diagnostic accuracy and image quality [1,2]. In our study, no significant difference was found in the diagnostic accuracy between low-tube-voltage (80 kVp) and conventional-tube-voltage (140 kVp) CTA protocols in 25 patients.

However, many technologic advances in CT techniques, such as iterative reconstruction, have been demonstrated to markedly improve the performance of low-dose CT acquisition [3]. Additionally, lowering tube voltage enhances the contrast attenuation in target vessels, thus maintaining a diagnostic CNR. As observed in our study, the mean image noise of the 80-kVp CTA protocol was statistically higher than that of the 140-kVp protocol; however, the image quality of the 80-kVp CTA protocol did not decrease despite the increase in noise [4].

In this study, no statistical difference was found in the diagnostic image quality between the low-dose CTA group and the conventional CTA group. Iterative reconstruction is regarded as an effective technology for improving image quality by reducing image noise with a CNR reduction of up to 13%. Our CTA protocol also would likely benefit from the application of iterative reconstruction techniques and the predicted increase in overall image quality [5,6].

Schuller [3] evaluated of image quality by four parameters as a Quantitative Analysis HU, SD, SNR and CNR. Calculation of HU for segment one of the right middle cerebral artery, The results showed that there was a statistically significant increase in all studied cases of group (1) compared to the control group (G2), also calculation of the SD for segment one of the right middle cerebral artery, The results showed that there was a statically significant increase in all studied cases of group (1) compared to the control group (G2). So using a low volume of contrast medium and tube voltage enhance the opacification of cerebral arteries without decreasing the image quality [7,8].

Where the mean CT attenuation values in low kV technique ranged from 278.6 to 601 HU. While in standard kV ranged from 160 to 400.1 HU. The minimum values of The mean CT attenuation values in low and standard kV techniques were (278.6, 160 HU) and the maximum was (601, 400.1 HU) respectively and cerebral blood vessel SD of image noise with low kV technique ranged from 18.8 to 95.8 HU while in standard kV technique the cerebral blood vessel SD of image noise ranged from 6 to 40.7 HU at the region of the right middle cerebral artery.

Calculation of the values of SNR for segment one of the right middle cerebral artery, the results showed that there was a statistically significant decrease in most of studied cases of group (1) compared to the control group (G2) . Calculation of the values of CNR for it, The results showed that there was a statistically significant increase in studied cases of group (1) compared to the control group (G2). So using a low volume of contrast medium and tube voltage enhance the opacification of cerebral arteries without decreasing the image quality [9,10].

Where the values of SNR for enhanced cerebral blood vessel with low kV technique ranged from 5.4 to 31.4 HU while SNR for cerebral blood vessel with in standard kV technique ranged from 6.5 to 41.4 HU. The values of CNR for enhanced cerebral blood vessels performed with low kV technique ranged from 27.7 to 102.7 HU. While CNR for cerebral blood vessels performed with Standard kV Technique ranged from 22.4 to 72.8 HU.

Qualitative image scoring was performed independently by two staff radiologists with experience in MDCT cerebral angiography examinations, the results showed that Image quality scores of standard kV technique including 2 patients with a score of 5 (8%), 17 patients with a score of 4 (68%) and 6 patients with a score of 3 (24%) while Image quality scores of low kV technique including 14 patients with a score of 5 (56%), 10 patients with a score of 4 (40%) and 1 patient with a score of 3 (4%) are listed in Table 4. In some patients, there was a similarity in image quality scoring between low and standard kV techniques. Wintersperger successfully compared the radiation dose and image quality between low and standard kV techniques obtained with 80 and 140 kVp of MDCT cerebral angiography examination. Reviewed 25 patients with cerebral vascularity disease by 64-slice MDCT device. The results showed that Calculation of the values of Computed tomography dose index volume (CTDIvol) for segment one of the right middle cerebral artery, there was a statistically significant decrease in all studied cases of group (1) compared to the control group (G2), also calculation of the values of dose length product (DLP) for it, there was a statistically significant decrease in all studied cases of group (1) compared to the control group (G2).

Calculation of the values of the dose reduction (DR) for it, there was a statistically significant decrease in all studied cases of group (1) compared to the control group (G2). Where CTDIvol values in Low kV technique ranged from 5.80 to 14.13 mGy while in Standard kV ranged from 30.40 to 54.71 mGy. And The range of DLP values in Low kV technique was 116.9 to 282.35 mGy while in Standard kV technique was 406.8 to 1060.4 mGy and The mean value of DR when using low kV technique was 46.93% comparing it with standard kV technique. So the low kVp protocol ensure that exposure of the patient to the radiation dose is significantly reduced [11].

As a final result of the present study, the dose of contrast medium and radiation given to the patient to perform a MDCT scan on the cerebral vascular system by using the low kilovolt technology was reduced by 38% and 40%, respectively while maintaining image quality.

Conclusion

Using a low volume of contrast medium and tube voltage enhance the opacification of cerebral arteries without decreasing the image quality and ensure that exposure of the patient to the contrast medium and radiation dose is significantly reduced.

References

1. Sun G, Ding J, Lu Y, Li M, Li L, et al. (2012) Comparison of standard-and low-tube voltage 320-detector row volume CT angiography in detection of intracranial aneurysms with digital subtraction angiography as gold standard. Academic Radiology 19: 281-288.
2. Luo S, Zhang LJ, Meinel FG, Zhou CS, Qi L, et al. (2014) Low tube voltage and low contrast material volume cerebral CT angiography. European Radiology 24: 1677-1685.
3. Geyer L L, Schoepf UJ, Meinel FG, Nance JW, Bastarrika G, et al. (schuller) State of the art: Iterative CT reconstruction techniques. Radiology 276: 339-357.
4. Macari M, Spieler B, Kim D, Graser A, Megibow A J, et al. (2010) Dual-source dual-energy MDCT of pancreatic adenocarcinoma: Initial observations with data generated at 80 kVp and at simulated weighted-average 120 kVp. American J Roentgenol 194: 27-32.
5. Donmez H, Serifov E, Kahriman G, Mavili E, Durak AC, et al. (2011) Comparison of 16-row multislice CT angiography with conventional angiography. Eur J Radiol 80: 455-461.
6. Bushberg JT, Boone JM (2011) The essential physics of medical imaging (3rd Ed.), Philadelphia: Lippincott Williams & Wilkins.
7. Bushberg JT, Seibert JA, (2011) For detection and evaluation of intracranial aneurysms. European Journal of Radiology 80: 455-461.
8. Funama Y, Awai K, Nakayama Y, Kakei K, Nagasue N, et al. (2005) Radiation dose reduction without degradation of low-contrast detectability at abdominal multisection CT with a low–tube voltage technique: phantom study. Radiology 237: 905-910.
9. Marin D, Nelson RC, Schindera ST, Richard S, Youngblood RS, et al. (2010) Low-tube-voltage, high-tube-current multidetector abdominal CT: Improved image quality and decreased radiation dose with adaptive statistical iterative reconstruction algorithm — initial clinical experience. Radiology 254: 145-153.
10. Tack D, Kalra MK, Gevenois PA (2012) Radiation dose from multidetector CT: Springer Science & Business Med.
11. Loftus ML, Minkowitz S, Tsiouris A J, Min RJ, Sanelli PC (2010) Utilization guidelines for reducing radiation exposure in the evaluation of aneurysmal subarachnoid hemorrhage: A practice quality improvement project. American J Roentgenol 195: 176-180.

Author Affiliations

Top

[1]*Department of Radiological Sciences and Medical Imaging Technology, Faculty of Applied Health Sciences Technology, Pharos University, Alexandria, Egypt*

[2]*Physics Department, Faculty of Science, Alexandria University, Alexandria, Egypt*

[3]*Medical Biophysics Department, Medical Research Institute, Alexandria University, Alexandria, Egypt*