LOW TUBE VOLTAGE CT LOWER LIMB ANGIOGRAPHY WITH AORTOGRAM: EFFECT ON RADIATION DOSE AND IMAGE QUALITY

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ABSTRACT

Purpose: Computed tomography angiography (CTA) is a non-invasive procedure to evaluate vascular anomalies. However, the high radiation dose related to the examination is a concern due to its associated cancer risk. Therefore, this study aims to investigate the effect of low tube voltage CT lower limb angiography with aortogram (CTLLA) on radiation dose and image quality based on body mass index.

Methods: Eighty patients were included in this study, where an initial 20 patients were scanned with standard dose protocol, irrespective of BMI. The remaining 60 patients were equally allocated to BMI-based protocol, where high and obese BMI was allocated to 120 kVp protocol, normal BMI to 100 kVp protocol, and low BMI to 80 kVp protocol. Dose data and image quality data were collected after the scan.

Results: The result showed a 75% reduction in radiation dose, a 40% increase in vessel attenuation for the 80 kVp protocol, and an improved qualitative image score.

Conclusion: In conclusion, tailoring the tube voltage with BMI can be used for CTLLA while achieving significant dose reduction without compromising image quality.

Key words: CT lower limb angiography with aortogram, Body mass index, Low tube voltage, Radiation dose, Image quality

INTRODUCTION

CT lower limb angiography with aortogram (CTLLA) is a commonly used imaging technique for assessing lower limb vessels. It is particularly effective in evaluating arteriosclerosis of the lower extremities (Napoli et al., 2011). Studies have shown that CTLLA has a sensitivity of 95% and a specificity of 96% for detecting and determining the extent of peripheral artery occlusive disease (PAOD) (Li et al., 2018; Met et al., 2009).

Despite CTLLA's high diagnostic accuracy, the procedure is associated with significant radiation exposure, which poses a risk for cancers such as lung and breast cancer (Parker et al., 2005; Schembri et al., 2010). This is particularly concerning given the substantial radiation dose emitted during the procedure. According to the linear non-threshold model, the risk of radiation-induced cancer exists even at low doses below 100 mSv (Berrington De González et al., 2009; Smith-Bindman et al., 2009). Therefore, it is essential to justify and optimize all CT examinations to reduce the risk of radiation-induced cancer (Ferrero et al., 2019). When a CTA examination is medically necessary, implementing dose optimization strategies in clinical practice is crucial (Tsapaki et al., 2021).

The radiation dose can be optimized using a number of strategies, including reduction of tube potential and tube current, limiting volume coverage by reducing the scan length, reducing rotation time, and increasing pitch, using automatic tube current modulation (ATCM) and adaptive dose shielding, and advancements in image reconstruction algorithms. (Ibrahim et al., 2014; Moser et al., 2017; Pradhan et al., 2021). However, only a few studies have been conducted in clinical practice. Although dose reduction is clinically feasible, a number of factors must be considered, such as image quality, noise, and reproducibility. Therefore, careful consideration should be given before implementing a dose reduction in medical imaging. This study aimed to evaluate the image quality of CT lower limb angiography with aortogram performed using a body mass index (BMI) based low-dose protocol.

MATERIAL AND METHODS

Approval for this study was obtained from the Institutional Ethics Committee (IEC-545/2018) and the Clinical Trials Registry of India (CTRI/2019/02/017593). Patients referred for CT lower-limb angiography with aortogram (CTLLA) were screened according to specific inclusion and exclusion criteria. The inclusion criteria required adult patients willing to participate by signing informed consent, while the exclusion criteria eliminated patients with trauma or those who were uncooperative. A total of 80 patients who underwent CTLLA were included in the study. Demographic data, including height and weight, were recorded to calculate body mass index (BMI). Initially, 20 patients were scanned using a standard dose protocol with 120 kVp (Protocol A, SD-120) regardless of BMI. The remaining 60 patients were divided into three groups of 20 each, assigned to low-dose protocols based on their BMI: overweight and obese patients were scanned using 120 kVp

(Protocol B, LD-120), normal weight patients with 100 kVp (Protocol C, LD-100), and underweight patients with 80 kVp (Protocol D, LD-80). All other scanning parameters, as listed in Table 1, were kept constant.

Table 1. Scanning parameters for CT lower limb angiography with aortogram

Protocol	Matrix size	Rotation time (sec)	Pitch	Slice Thickness (mm)	idose	Collimation	DRI
Standard dose protocol	512x512	0.5	0.8	1	3	64*0.625 mm	16
Low dose protocol	512x512	0.6	0.6	1	4	64*0.625 mm	16

The Data such as mA, mAs, scan length, volumetric computed tomography dose index (CTDIvol), and dose length product (DLP) were collected after the scan. DLP was further used to calculate the effective dose (edose) using the conversion factor suggested by Christner et al. (Christner et al., 2010). Images were reconstructed, and the maximum intensity projection (MIP) images with routine batching protocol in axial, coronal, and sagittal orientation and source image with 5 mm thickness were sent to PACS. Quantitative and qualitative image analyses were performed on acquired images.

Quantitative analysis

Quantitative image analysis was conducted using an IntelliSpace Portal (ISP) workstation, where regions of interest (ROIs) were placed within blood vessels and adjacent muscles during the CT angiography phases. The ROIs were positioned on the following blood vessels: right and left common iliac arteries (CIA), internal iliac arteries (IIA), external iliac arteries (EIA), femoral arteries (FA), deep femoral arteries (DFA), popliteal arteries (PA), anterior tibial arteries (ATA), peroneal arteries (PrA), posterior tibial arteries (PTA), and plantar arches (PLA). The signal attenuation for each ROI was measured in Hounsfield units (HU). Image noise was quantified as the standard deviation (SD) within each vessel ROI. The signal-to-noise ratio (SNR) was calculated by dividing the mean signal attenuation of the vessel by the vessel's SD (mean signal attenuation/SD). The contrast-to-noise ratio (CNR) was determined by subtracting the mean signal attenuation of adjacent muscles from the mean signal attenuation of the vessels and then dividing by the vessel noise (SD of vessels): (mean signal attenuation of vessels – mean signal attenuation of adjacent muscles)/SD of vessels.

Qualitative Analysis

Qualitative analysis was performed using the PACS viewer by two radiologists with minimum of 6 years of experience in CT angiography who were blinded from kVp and mA settings graded the image quality on quality criteria: (a) Vascular Delineation (Q1), (b) Certainty of Diagnosis (Q2), (c) Vessel contrast and overall image quality (Q3), and (d) Image artefacts (Q4) using 5 points Likert scale (table 2)

Table 2. Grading of quality criteria

Quality criteria	1	2	3	4	5
Q1	Cannot be identified	Less than 50 %	More than 50% but less than 75%	More than 75%	Entire length
Q2	Uncertainty	Marginal certainty	Adequate certainty	Good certainty	Full and confident certainty
Q3	Unacceptable	Marginally accepted	Adequate	Good	Excellent
Q4	Affecting decision making	Pronounced	Moderate	Mild	Complete absence

Statistical Analysis

Data analysis was performed using Jamovi (2.3.24). Each independent variable was initially checked for normality using the Shapiro-Wilk test. Normally distributed data ($p>0.05$) were reported as mean and standard deviation (mean ± SD), whereas data that were not normally distributed ($p<0.05$) were reported as medians with the 25th and 75th quartiles. The decision on whether to use the analysis of variance (ANOVA) or Kruskal Wallis (KW) test to determine intergroup differences was decided according to the ANOVA assumption. The variables meeting the assumption were analyzed using ANOVA (Fisher’s) test with post-hoc test (Tukey). Variables with failed assumptions used the KW test to determine intergroup differences and the Dwass-Steel-Critchlow-Fligner (DSCF) test for pairwise comparison. Furthermore, for the data that were normally distributed but failed the homogeneity test (Levene’s test), we used ANOVA without assuming equal variance (Welch’s test) and post-hoc (Games-Howel test). Intergroup differences in qualitative data were analyzed using the KW test. Kappa statistics were used to determine inter-rater agreement. The level of significance was set at $p<0.05$.

RESULTS

Patient Parameters and scan parameters

Descriptive statistics for patient parameters and scanning paraments for CT lower limb angiography with aortogram are given in table 3. The scanning parameters showed increase in the mA and mAs value when the tube voltage was reduced from 120 kVp to 80 kVp. The difference in mA and mAs between standard dose and low dose parameters were statistically significance. The post-hoc analysis showed that the mA value was not statistically significant between low dose protocol B and C, and protocol C and D. The post-hoc result of mAs value shows statistically significant difference between all the combinations. Scan length for angiography phase were statistically significant. However, the post-hoc result shows the significant difference in scan length were noted between protocol A and D, and protocol B and D.

Radiation dose parameters

The radiation dose values obtained for CT lower limb angiography with aortogram is presented in table 3. The result revealed that the radiation dose was reduced significantly between standard dose and low dose protocols. Post-hoc analysis also shows significant difference between all the combinations for CTDIvol, However, in terms of DLP and effective dose the post-hoc shows that the no significant difference between protocol B and C. A total of up to 75% dose reduction was achieved for all the three dose descriptors when scanned with 80 kVp protocol.

Quantitative Data

The mean attenuation values of lower limb vessels are represented in table 4. The result shows that the low dose protocol (protocol D) resulted in increase in the vessels attenuation up to 40% as compared to standard dose protocol (Protocol A). Looking at the variance of mean vessels attenuation value among different protocol the value showed statistically significance difference ($p<0.001$). The result from post-hoc analysis shows the statistical significance difference for all the combination except, between protocol A-B. When considering individual lower limb vessels, the variance in the mean across all the protocol were statistically significance ($p<0.001$). However, the post-hoc result of individual vessels showed no significant difference between protocol A-B for all the individual vessels. Similarly, no significant difference was noted between protocol B-C for the vessels PrA, and PLA and protocol C-D for vessels ATA, PrA, PTA, PLA. Figure 1 shows the increase in mean lower limb vessel attenuation value while using low dose protocol.

Image noise was noted to be highest in protocol D (LD-80) (up to 22% increase compared to protocol D (SD_120)) and the variance in the mean was statistically significance ($p<0.001$). However, the post-hoc test shows statistical significance difference only between protocol A-D, and B-D. In terms of SNR and CNR, the highest value was noted for protocol C (LD-100), but the difference between SNR ($p=0.780$) and CNR ($p=0.490$) across different protocol was not statistically significance (table 4). Figure 1 shows the increase in noise, SNR and CNR value while using low dose protocol.

Qualitative Analysis

Quality criteria score for lower limb vessels are represented in table 5. For all the quality criteria score was graded highest for low dose protocol D (LD-80). However, no instance of low score less than 4 was noted for quality criteria 1, 2, and 4. For quality criteria 3 the lowest score of 3 (adequate vessel contrast and overall image quality) was noted for protocol A (SD-120) with score of 1. Mean quality score (table 6) for quality criteria 1 and 3 shows statistically significant difference between different protocol. However, no significant difference was noted for quality criteria 2 and 4 between protocols. The inter-rater agreement shows kappa value of 0.530 ($p<0.001$), and 0.457 ($p<0.001$) for quality criteria 1 and 3 respectively. For quality criteria 2 and 4, since all the quality score were 5 for both the readers except for protocol B (LD-120) (table 5), the kappa value was not generated. Figure 2, 3, 4, and 5 shows the axial section, coronal section, and volume rendering and maximum intensity projection images respectively, scanned with four different protocol.

Table 3. Descriptive of patient parameters, scanning parameters and radiation dose for CT lower limb angiography

Parameters	SD_120 (A)	LD_120 (B)	LD _100 (C)	LD _80 (D)	P value (ABCD)	P value (AB)	P value (AC)	P value (AD)	P value (BC)	P value (BD)	P value (CD)
¶ Age	54.1 ± 15.2	58.0 (36.5, 65.0)	52.0 ± 14.1	66.5 ± 7.98	< 0.001	0.993	0.967	0.017	0.998	0.010	0.002
BMI	22.5 ± 3.15	27.2 (26.3, 28.9)	22.2 ± 1.51	16.6 ± 0.832	< 0.001	< 0.001	0.965	< 0.001	< 0.001	< 0.001	< 0.001
Scan Parameters											
mA	239 (239, 239)	134 (124, 151)	155 ± 17.2	165 (161, 173)	< 0.001	< 0.001	< 0.001	< 0.001	0.149	0.021	0.528
mAs	149 (149, 149)	83.5 (78.0, 94.3)	116 (115, 117)	128 ± 1.35	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Scan length	1429 (1301, 1495)	1217 (1188, 1453)	1466 (1202, 1546)	1503 (1500, 1516)	< 0.001	0.057	1.000	0.016	0.080	< 0.001	0.981
Radiation dose											
$CTDI_{vol}$ (mGy)	12.2 (12.2, 12.2)	6.81 (6.33, 7.69)	5.65 ± 0.158	2.97 (2.55, 3.00)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
DLP (mGy*cm)	1819 (1662, 1905)	903 (808, 1162)	821 (723, 902)	468 (375, 480)	< 0.001	< 0.001	< 0.001	< 0.001	0.242	< 0.001	< 0.001
Effective dose (mSv)	11.8 (10.8, 12.4)	5.87 (5.25, 7.55)	5.33 (4.70, 5.86)	3.04 (2.44, 3.12)	< 0.001	< 0.001	< 0.001	< 0.001	0.242	< 0.001	< 0.001

¶ Normally distributed but equal variance not assumed (welch's test) Post hoc Games-Howell

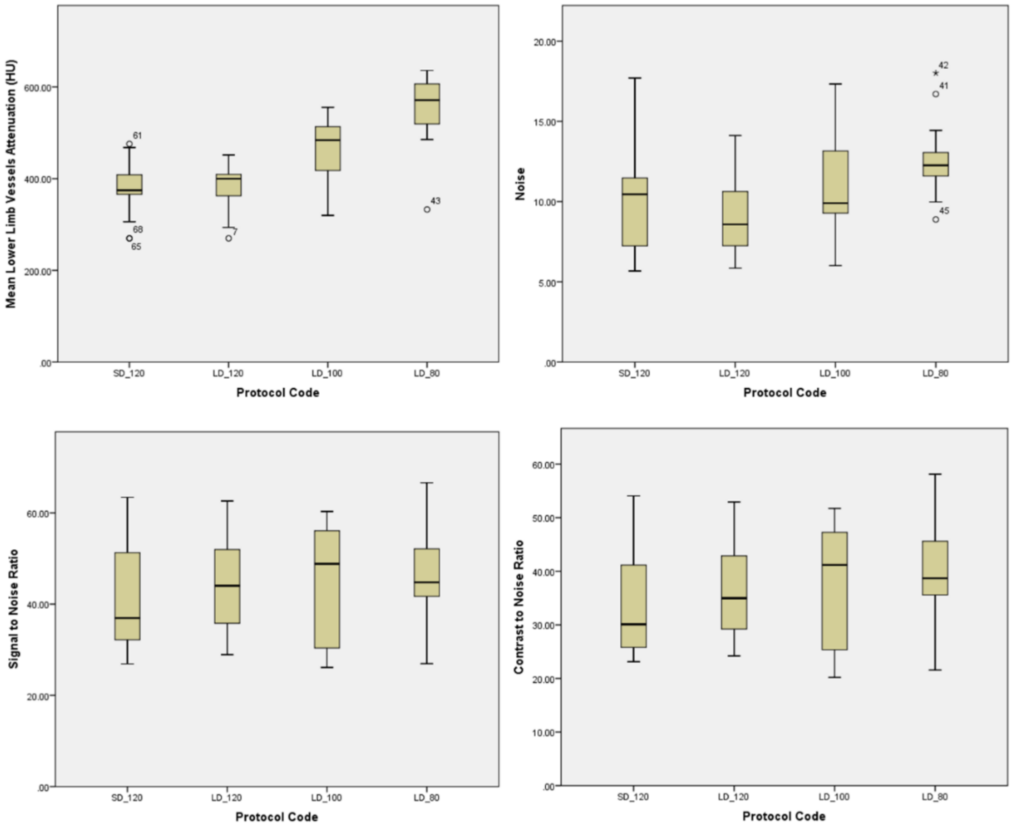

Figure 1. Bar graph showing the quantitative image quality values for standard dose and low dose protocols

Table 4. Descriptive of lower limb vessels attenuation values, noise, Signal-to-noise ratio, and contrast-to-noise ratio

Parameters	SD_120 (A)	LD_120 (B)	LD _100 (C)	LD _80 (D)	P value (ABCD)	P value (AB)	P value (AC)	P value (AD)	P value (BC)	P value (BD)	P value (CD)
CIA	412 ± 58.0	404 ± 43.2	487 ± 59.2	661 (610, 682)	<0.001	1.000	0.002	<0.001	<0.001	<0.001	<0.001
IIA	398 ± 64.4	391 ± 49.0	492 (426, 516)	625 (580, 648)	<0.001	0.982	0.032	<0.001	0.008	<0.001	<0.001
EIA	422 (393, 441)	413 (389, 424)	485 ± 61.8	645 (575, 685)	<0.001	0.709	0.004	<0.001	<0.001	<0.001	<0.001
FA	435 ± 58.2	425 (401, 447)	489 ± 61.4	650 (578, 675)	<0.001	0.503	0.037	<0.001	0.001	<0.001	<0.001
DFA	409 ± 53.0	405 (390, 419)	490 ± 56.9	619 (557, 644)	<0.001	0.779	<0.001	<0.001	<0.001	<0.001	<0.001
PA	427 ± 56.8	415 (398, 442)	482 ± 68.4	618 (551, 651)	<0.001	0.700	0.046	<0.001	0.008	<0.001	<0.001
ATA	357 (229, 406)	398 (312, 407)	500 (363, 519)	515 (434, 561)	<0.001	0.615	0.006	<0.001	0.028	<0.001	0.462
PrA	319 ± 81.6	367 (312, 407)	464 (320, 499)	468 (412, 507)	<0.001	0.607	0.034	<0.001	0.118	<0.001	0.765
PTA	332 ± 79.1	348 ± 55.8	438 ± 93.5	503 (440, 543)	<0.001	0.980	0.005	<0.001	0.014	<0.001	0.408
PLA	274 ± 107	328 ± 64.6	484 (290, 498)	451 (407, 490)	<0.001	0.350	0.014	<0.001	0.125	<0.001	1.000
Mean Vessels	380 ± 54.4	381 ± 46.3	462 ± 68.9	571 (524, 604)	<0.001	0.996	0.004	<0.001	0.003	<0.001	<0.001
Noise (Vessel SD)	9.86 ± 3.20	8.97 ± 2.11	11.1 ± 2.88	12.3 (11.6, 13.0)	<0.001	0.885	0.684	0.009	0.118	<0.001	0.159
Mean Muscle	67.5 (66.7, 68.7)	68.7 (66.9, 69.3)	74.9 ± 2.24	75.9 ± 2.00	<0.001	0.409	<0.001	<0.001	<0.001	<0.001	0.521
SNR	41.7 ± 11.6	44.4 ± 10.3	48.8 (30.8, 56.0)	45.6 ± 10.1	0.780	0.749	0.962	0.733	0.999	0.977	0.993
CNR	30.1 (25.9, 40.7)	36.4 ± 8.96	41.2 (25.7, 47.1)	39.5 ± 9.36	0.490	0.667	0.916	0.397	0.998	0.667	1.000

Table 5. Quality criteria score for CT Lower limb angiography with aortogram

Protocol	Quality criteria 1		Quality criteria 2		Quality criteria 3			Quality criteria 4	
	4	*5*	*4*	*5*	*3*	*4*	*5*	*4*	*5*
SD_120	12	28	0	40	1	10	29	0	40
LD_120	6	34	1	39	0	10	30	1	39
LD_100	15	25	0	40	0	6	34	0	40
LD_80	2	38	0	40	0	2	38	0	40

Table 6. Mean quality score for CT Lower limb angiography with aortogram

Quality criteria	SD_120	LD_120	LD_100	LD_80	p-value
1	4.70 ± 0.464	4.85 ± 0.362	4.63 ± 0.490	4.95 ± 0.221	0.002
2	5.00	4.97 ± 0.158	5.00	5.00	0.392
3	4.70 ± 0.516	4.75 ± 0.439	4.85 ± 0.362	4.95 ± 0.221	0.035
4	5.00	4.97 ± 0.158	5.00	5.00	0.392

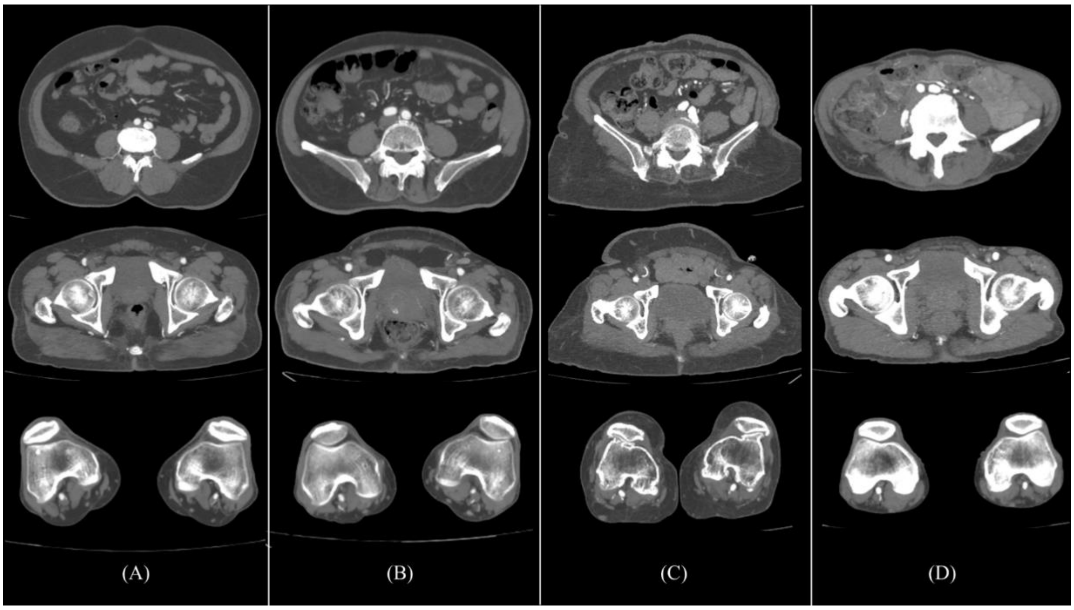

Figure 2. An axial image of a lower limb vessels. CT images of a (A) 55 years old male patients scanned with protocol A, (B) 72 years old male patients scanned with protocol B, (C) 70 years old female patient scanned with protocol C, and (D) 63 years old male patient scanned with protocol D.

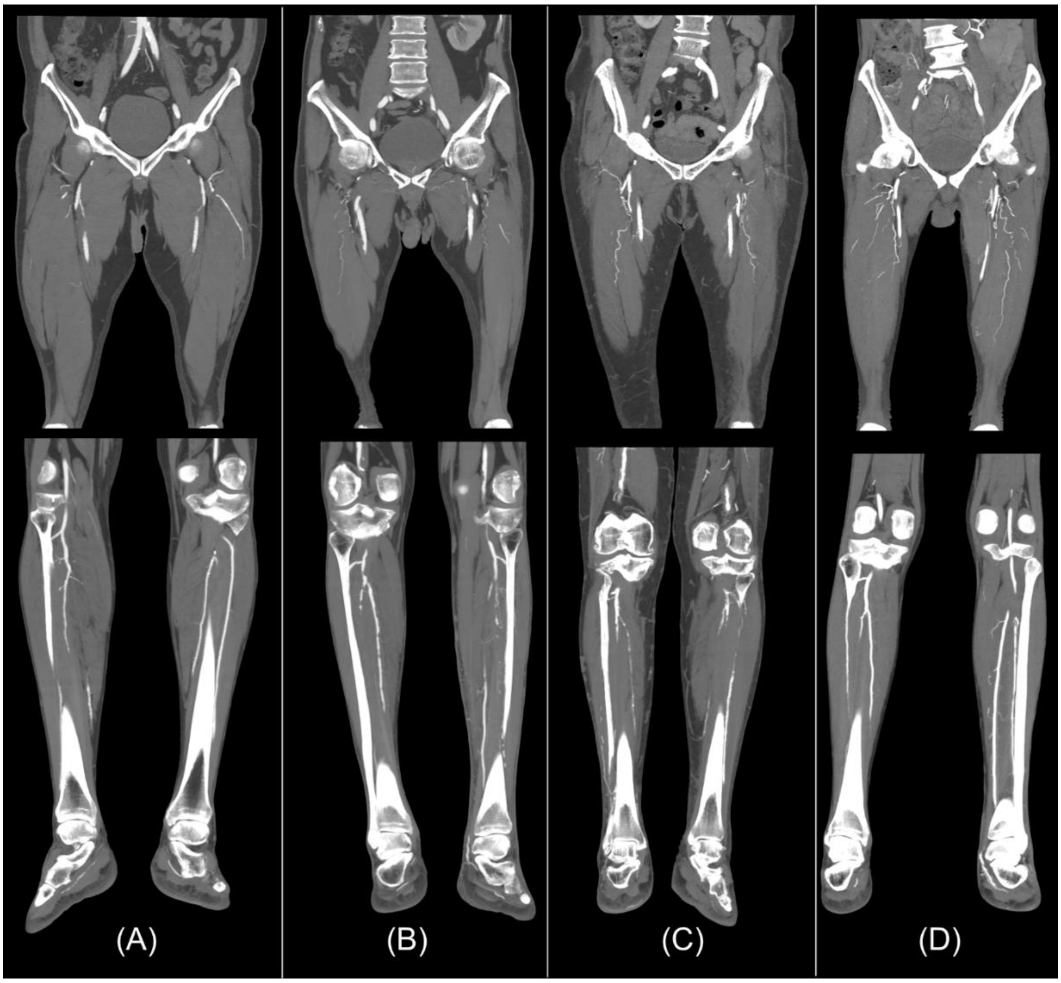

Figure 3. A coronal image of a lower limb vessels. CT images of a (A) 55 years old male patients scanned with protocol A, (B) 72 years old male patients scanned with protocol B, (C) 70 years old female patient scanned with protocol C, and (D) 63 years old male patient scanned with protocol D.

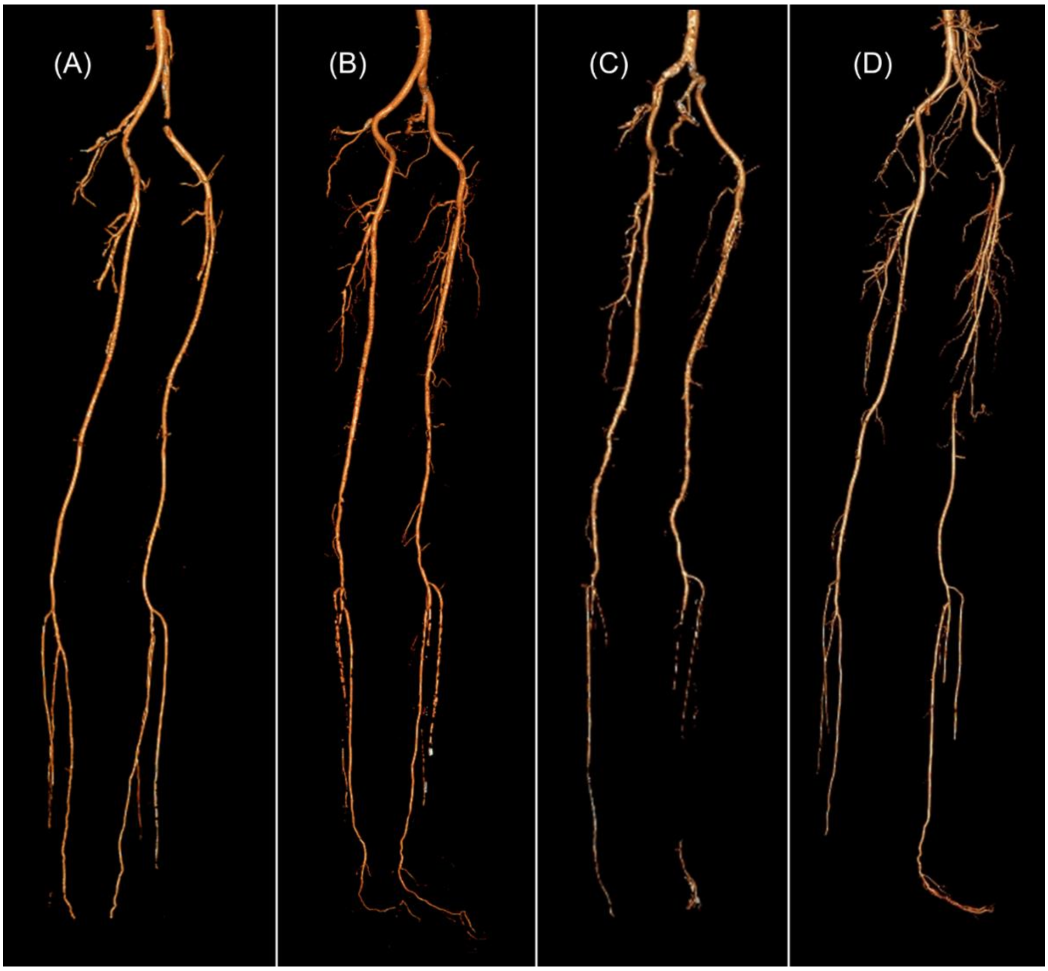

Figure 4. A VR image of a lower limb vessels. CT images of a (A) 55 years old male patients scanned with protocol A, (B) 72 years old male patients scanned with protocol B, (C) 70 years old female patient scanned with protocol C, and (D) 63 years old male patient scanned with protocol D.

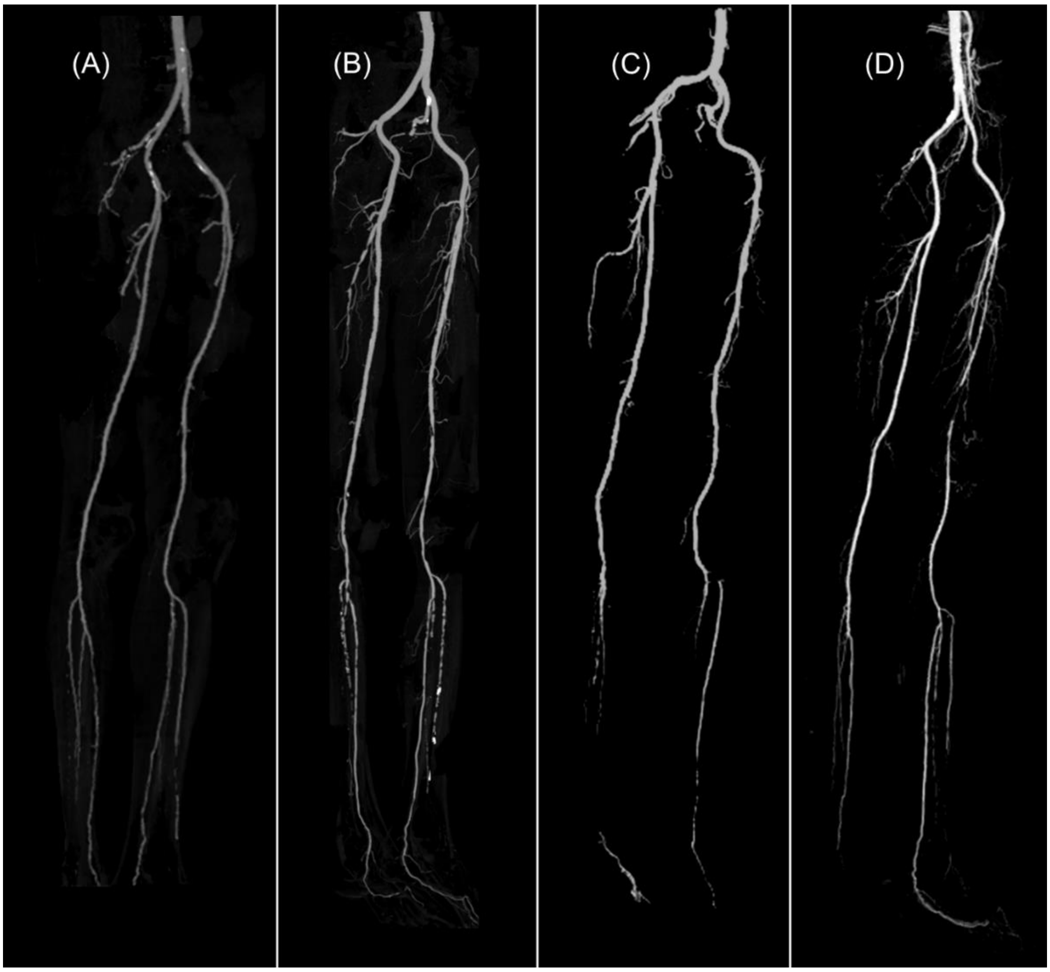

Figure 5. A MIP of a lower limb vessels. CT images of a (A) 55 years old male patients scanned with protocol A, (B) 72 years old male patients scanned with protocol B, (C) 70 years old female patient scanned with protocol C, and (D) 63 years old male patient scanned with protocol D.

DISCUSSION

Among the different strategies to reduce radiation dose in CT examinations, lowering the tube voltage is the most preferred, as the radiation dose is proportional to the square of the tube voltage. (C. W. Chen et al., 2019; Utsunomiya et al., 2010). This strategy is particularly effective in contrast-enhanced examinations, especially in CT angiography, because reduced tube voltage leads to increased iodine enhancement. This is mainly due to the rise in the photoelectric effect as the mean photon energy of the lower tube voltage approaches the K-edge of iodine. (Cho et al., 2015; Georgiev et al., 2019; Nakayama et al., 2006). In this study, we observed that using the low dose protocol (LD-80) resulted in up to a 40% increase in contrast enhancement, while simultaneously achieving a radiation dose reduction of over 75%. However, this strategy of lowering the tube voltage was adjusted based on the patient's BMI, as applying low-kVp techniques uniformly across all patient sizes may not be suitable due to higher attenuation in larger patients. (E. L. Chen et al., 2017).

Reducing tube voltage to lower radiation dose for patients has the disadvantage of increased image noise, which could affect diagnostic decisions (Sodickson et al., 2012). However, this issue can be mitigated by raising the tube current and employing iterative reconstruction techniques (Padole et al., 2015; Ramgren, Björkman-Burtscher, Holtas, et al., 2012). In our study, we observed a notable increase in tube current when tube voltage was reduced, owing to ATCM. We also utilized iterative reconstruction (iDose^{4}™ by Philips Healthcare) for all scans, which significantly controlled noise levels with only a 22% increase in noise for CTLLA examinations at low tube voltage. Previous studies (Georgiev et al., 2019; Sun et al., 2012; Zamboni et al., 2012) have also reported higher noise levels in low-dose protocols compared to CT angiography at 120 kVp, though the degree of noise increase differed. For example, Georgiev et al. (Georgiev et al., 2019) reported a 124% increase in noise with the 80 kVp protocol.

In CT angiography, vessel enhancement is a critical criterion for image quality, as higher enhancement enables a wider window width for better vessel delineation (Ramgren, Björkman-Burtscher, Holtås, et al., 2012). Low tube voltage techniques can enhance vessel visibility, as observed in our study and supported by other studies (P. A. Chen et al., 2019; Hu et al., 2017; Liu et al., 2018). We recorded a 40% increase in vessel enhancement as the tube voltage was reduced. A similar outcome was reported by B. Liu et al. (Liu et al., 2018) who observed up to a 45% increase in attenuation with 80 kVp techniques for lower limb vessels. Although Liu et al. reduced contrast volume from 100 ml at 120 kVp to 75 ml at 80 kVp, the percentage increase in vessel attenuation was comparable to our findings. In our study, we did not reduce contrast volume or iodine concentration, as renal function tests were conducted before CT angiography to mitigate the risk of renal toxicity, following our institute's protocol. For patients with elevated creatinine levels, we substituted Omnipaque 350 mg/ml with Visipaque 270 mg/ml, excluding these cases from our study criteria. However, reducing both iodine concentration and contrast volume could be a viable strategy in low tube voltage techniques to minimize renal toxicity without compromising vessel enhancement (Dangas et al., 2005; Ebisawa et al., 2016).

The advantage of higher vessel enhancement with low tube voltage settings showed improvement in quantitative image quality matrix SNR and CNR. In the present study, the SNR and CNR values for lower limb vessels increased with low tube voltage techniques. This result showed shared opinions between the improvement and degradation of SNR and CNR of the vessels with low tube voltage techniques in the literature. B. Liu et al., (Liu et al., 2018) for lower limb vessels, reported increased SNR and CNR values with low tube voltage settings, whereas, Emil Georgiev et al., (Georgiev et al., 2019) reported lower SNR and CNR values with low tube voltage techniques. This inconsistency in findings might be due to the use of reconstruction techniques in their studies. In our study, we used iterative reconstruction idose4^{TM} (Philips healthcare), which showed improved noise reduction with low tube voltage techniques, therefore, increasing the SNR and CNR values. Regarding qualitative image quality, the mean quality score for the low tube voltage settings of 80kVp was significantly higher than other tube voltage settings in the present study. Similar results were noted with the study in the literature (Liu et al., 2018).

The use of low tube voltage settings in this study led to a significant reduction in radiation dose, as measured by CTDIvol, DLP, and effective dose. A reduction of up to 75% was observed across all three dose descriptors for CT lower limb angiography with aortogram. Similar levels of dose reduction have been reported in the literature when using 80 kVp techniques compared to 120 kVp techniques. However, the study by B. Liu et al. (Liu et al., 2018) reported even lower CTDIvol and DLP values, likely due to their use of a lower maximum mA. Additionally, W.-L. Qian et al. (Qian et al., 2018) observed lower radiation doses by using a noise index of 12 for 120 kVp settings, a noise index of 1 for 80 kVp settings, and 20 mA with 80 kVp settings. This resulted in lower radiation doses compared to the current study, where the noise index remained unchanged. It is also important to note that the dose data in this study were collected specifically for CT lower limb angiography with aortogram, whereas the studies referenced focused solely on CT lower limb angiography. This difference likely contributes to the variation in radiation dose observed.

There are a few limitations in our study. Firstly, the intra-individual comparison of radiation dose and image quality was not performed due to ethical issues. Although it is the best method for proper comparison, exposing the patient multiple times for study is unethical. Secondly, in this study, no contrast volume contrast concentration and flow rate were adjusted. Although doing so, the contrast load to the patient can be reduced, especially with low tube voltage techniques. Furthermore, no vascular disease evaluation was performed in the present study. The image quality result with low tube voltage settings for all the vessels was promising, but further studies can be conducted considering the vascular disease evaluation. Lastly, we did not change the dose right index (also known as noise index) in our study. The effect of the dose right index can be explored in future studies to reduce radiation dose further so that an achievable dose can be established.

CONCLUSION

Lowering the tube voltage according to patient BMI can significantly reduce radiation dose, enhancing our ability to provide excellent patient care. In our study, we observed a substantial reduction in radiation dose for CT lower limb angiography with aortogram. The benefits of reducing tube voltage extended beyond just lowering radiation exposure; it also led to significantly improved vessel enhancement, which in turn increased the SNR and CNR of the images, resulting in better image quality. Therefore, we can conclude that reducing tube voltage allows for a lower radiation dose without compromising diagnostic confidence.

STATEMENT AND DECLARATION

Funding: This research received no external funding.

Ethics statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of Kasturba Hospital, Manipal (IEC-545/2018). Informed consent was obtained from all subjects involved in the study.

Disclosure: No potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Pradhan A, Sukumar S. Data curation: Pradhan A, Kadavigere R. Formal analysis: Pradhan A, Dkhar W. Investigation: Pradhan A, Dkhar W. Methodology: Pradhan A, Kadavigere R, Sukumar S, Dkhar W. Software: Pradhan A, Dkhar W. Validation: Pradhan A, Kadavigere R, Sukumar S. Visualization: Pradhan A. Writing - original draft: Pradhan A, Dkhar W. Writing - review & editing: Kadavigere R, Sukumar S.

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