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Assessing Upper Limb Angiography Effective Dose With 128-Slice Multi Detector Computed Tomography

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ABSTRACT

Introduction: Computed Tomography (CT) provides high-resolution imaging, particularly useful in evaluating bone-related musculoskeletal disorders. The effective dose is an ideal measurement to compare the radiation dose levels of various imaging modalities. The primary aim of this study was to assess the effective dose of radiation delivered during upper limb angiography using 128-slice CT and evaluate its safety and effectiveness.

Methods: In this retrospective study, the CT scans were performed using 128 slices of GE Health Care (GE Revolution). For each scan, the machine automatically generated a radiation dose report. This report included the dose-length product (DLP), and the data were stored in PACS, from which the effective dose for the study was calculated using standard conversion coefficients.

Results: Total of 18 patients aged 20–75 years, with average mean 47.0± 14.91 years, who underwent upper limb angiography were included. The average DLP was 16.66 mGy-cm ± 9.48 mGy-cm and average Mean of CTDI vol was 33.32 mGy ±18.96 mGy and, average Mean of ED is 0.25 mSv ± 0.14 mSv. This ED was lower than European DRL. All scans produced diagnostically acceptable images.

Conclusion: The Radiation effective dose in upper limb angiography was found to be low, while providing diagnostically acceptable images for clinical assessment. Patient outcomes and image quality can be improved by optimizing imaging protocols, utilizing advanced technologies, and enhancing clinician awareness of radiation safety.

Keywords: Computed tomography angiography; Effective dose estimation, Upper limb Angiography, Radiation dose assessment, Dose Length Product

INTRODUCTION

Computed Tomography (CT) provides better spatial resolution and 3-D detail when evaluating bone-related musculoskeletal disorders, helping physicians with diagnostic and preoperative planning [1]. Aneurysms, stenosis, blockages, blood clots, vascular malformations, congenital anomalies, ruptures, injuries, and tumors are a few related conditions for which Computed Tomography Angiography (CTA) helps in the non-invasive diagnosis and evaluation of blood vessel disease [2] (Fig1). However, because of quicker multi-detector scanners that provide better spatial and temporal resolution, CTA of the upper

extremities has become increasingly common over the past decade [3]. Compared to regular radiography, a standard CT scan exposes the patient to a much higher radiation dose.
The effective dose (ED) is an ideal measure for comparing the radiation dose levels of various imaging modalities and atmospheric background radiation, as well as for comparing the stochastic radiation risk associated with medical imaging with the risk involved with other human activities[5]. ED-incorporated organ-specific radiation sensitivity weighing factors were approved by the International Commission on Radiological Protection (ICRP) to produce a single metric in mSv that correlates with stochastic risk, such as lifetime cancer probability[8].
To the best of our knowledge, very few studies have assessed the effective dose in CT upper limb angiograms. Most of the literature is centred around segmental dose analysis. The primary aim of this study was to assess the effective dose of radiation delivered during upper limb angiography using 128-slice multidetector computed tomography (MDCT) and evaluate its safety and effectiveness[6].

Figure1: CT upper limb angiogram

MATERIALS AND METHOD

Study design

This retrospective observational study was performed using a CT GE HealthCare 128 Slice (GE Revolution) scanner at the Father Muller Medical College's Department of Radio Diagnosis and imaging for six months, between September 2024 and February 2025 after ethical approval from the Father Muller Institutional Ethics Committee (FMIEC).

Ethics statement

The waiver of consent was based on the fact that the research involves minimal risk, there is no direct contact between researcher and patient, the rights of any participant will not be violated during and after the completion of this study, the participants' details will not be disclosed to anyone, thereby protecting the confidentiality and privacy of the participants.

Study Population

All patients who were referred for upper limb angiography to the radiology department's computed tomography scan during the study period were aged between 20 and 60 years, and DLP and CTDIvol readings were recorded. Patients aged < 20 and > 60 years, incomplete dose data, or any allergic patients specifically to contrast used were excluded.

Sample size

The sample size (n) was calculated using the following formula: $n = (Z\alpha^2 \times \sigma^2) / E^2$. Where $Z\alpha$ is the critical value for the 95% confidence interval (1.96), σ is the standard deviation (0.11), and E is the error margin (5%)[1]. Based on these values, the required sample size was determined to be approximately 18.

Scan Protocol

All scans were performed using GE 128 Slice Revolution MDCT. Patients were positioned supine with arms extending upward to avoid beam-hardening artifacts. The scan protocol used was as follows: slice thickness, 1.250 mm; gantry tilt 0, SFOV;, large; tube voltage: 120 kV, Tube current, 440 mA; rotation time: 0.35 s, total exposure was for 15.16 s and prep group delay 4.1 s, reconstruction algorithm, iterative reconstruction technique: ASiR-V (Advanced Statistical Iterative Reconstruction with Volume). The bolus tracker ROI was kept at the descending abdominal aorta, and 100 ml non-ionic iodinated contrast (350 mg I/ml) was administered following 40 ml saline flush at a flow rate of 4 ml/sec via the antecubital vein.

Dose measurement

For each examination, the scanner automatically generated the total body radiation dosage based on the dose-length product (DLP) and was exported to the PACS image information, where it was stored. The effective dose was calculated using the mathematical equation $E = DLP \times k$ [1]. In this formula, DLP is the dose length product, K is the conversion coefficient (mSv mGy-1 cm-1), and the value of k for the upper limb Anglo is 0.015 mSv mGy-1 cm-1[1,9].

Statistical Analysis

Data were analysed using the Statistical Package for Social Sciences (SPSS) version 23.0. Descriptive statistics for demographic variables were expressed as mean ± SD, range (min-max), median (IQR) for age, and sex. Frequency and percentage were measured.

Descriptive statistics for clinical variables were computed as mean ± standard deviation (SD), range (min-max), and median (IQR) for DLP, CTDIvol, and ED.

Results:

Eighteen patients, 12 (66.7%) males and 6 (33.3%) females between the ages of 20 and 75 years underwent CTA on 128 slice MDCT. The mean ± SD of age was 47.1 ± 14.9, median (IQR) of 48 (57-31) (Table 1).

Table 1: Demographic variables

	Frequency	Percentage
Male	12	66.7
Female	6	33.3
Total	18	100

The mean ± SD for DLP was 16.66 ± 9.48 mGy-cm, mean ± SD for CTDIvol was 33.33 ± 18.96 mGy, and mean ± SD for effective dose (ED) was 0.25 ± 0.14 mSv as shown in table 2.

Table 2: Clinical Variables

	Mean ±SD	Range (min-max)	Median (IQR)	Reference Benchmark
DLP (mGy-cm)	16.66 ±9.48	7.89-35.52	12.82(25.65- 9.37)	279-8374 mGy-cm
CTDIvol (mGy)	33.33 ±18.96	15.79-71.04	25.65(51.31- 18.74)	2.3-23 mGy
ED (mSv)	0.25 ±0.14	0.11-0.53	0.19 (0.38–0.14)	Background radiation (3mSv/yr),Head CT 2mSv

The mean (DLP) of 16.7 mGy-cm lies far below the range of the European DRL reflecting optimized, limited scan length. A mean ED of 0.25 mSv represents roughly one month of background radiation and is substantially lower than CT head/chest which is 2-7 mSv and background radiation of 3 mSv/year and UK-DRL. Mean CTDI vol of 33.4 mGy is slightly higher than the upper limit of the reference DRL likely due to protocol settings. The moderate SD in DLP and CTDI vol indicates the possible influence of patient anatomy and scan parameters. A low mean ED can indicate minimal stochastic risk, supporting its clinical use. These findings demonstrate the viability of MDCT as a safe, dependable, and minimally invasive imaging modality for upper-limb angiography and provide a reference for future quality control of extremity CTA [10-12].

DISCUSSION

This study quantified the ED of 18 upper limb angiography on 128 slice MDCT and the mean ED was 0.25 ±0.14 mSv. This value is low compared to those reported in previous studies. Most upper limb CTA studies are single-centre, small cohorts (n=14-312), limiting generalizability; six such studies were analysed and compared with our findings.

Sorin Daniel et al.[1] studied 312 patients and calculated mean dose of each part, omitting whole limb ED, they found mean effective doses as follows: wrist CT, 0.07 mSv; elbow, 0.11 mSv; and shoulder, 6.36 mSv. Our combined limb approach falls between their wrist/elbow values, and is lower than their shoulder CT values. Binkert et al.[7] studied 14 patients and found a mean dose of 0.22 mSv which was closely aligning with our study. Compared to the European reference DRLs [11] our mean ED is substantially lower, indicating the safe use of the low ED in MDCT, in contrast to other angiographic modalities, resulting in less radiation-induced damage. MDCT can be used as a non-invasive alternative to conventional angiography (5-10mSv per procedure) and has a lower stochastic risk associated with ionizing radiation in younger patients.

Pradhan et al. [13] reported 26 patients who underwent upper limb angiography and the mean ED was 2.93mSv, much higher than our mean ED on 128 slice CT. Biswas et al. [14] evaluated effective dose of 20 upper limb CT retrospectively and reported ED for different parts like shoulder (2.06 mSv) was higher than those of the elbow (0.14 mSv) and wrist (0.03 mSv), our mean ED again fell in between their wrist and elbow values. Lalone et al.[15] calculated the average ED of the shoulder to be 10.44 mSv. Boothe et al.[16] conducted a study on 120 shoulder CT scans based on body mass index and found that the mean volume CT Dose index (CTDIvol) and dose-length product (DLP) were 30±20 mGy and 658±479 mGy-cm, whereas our mean CTDIvol was slightly higher: 33.33 ±18.96 mGy, and DLP was significantly lower:16.66 ±9.48 mGy-cm, which might imply more efficient scanning protocol therefore enhancing patient safety due to harmful effects of radiation.

The use of modern 128 slice MDCT with Advanced Tube Current Modulation (ATCM) and iterative reconstruction algorithm was the first procedure-specific ED for upper-limb angiography in our region. Future studies should focus on determining size-specific diagnostic reference levels (SS-DRLs) for extremity computed tomographic angiography (CTA), relating effective dosage to objective image-quality indicators (such as signal-to-noise ratio and diagnostic confidence ratings), and evaluating long-term patient results to enhance protocol guidelines. Conducting multicentre research with larger, more varied participant groups will increase applicability and facilitate subgroup analysis based on age, sex, and body composition.

The sample size of the study was limited to 18 patients, and the data were collected retrospectively from a single institution, which may not represent the broader population of patients undergoing upper limb angiography and the limited subgroup analysis. There was also a lack of image quality scoring and clinical outcome correlations, which may restrict the use of ED benchmarks across a broader population.

CONCLUSION

In conclusion, the mean effective dose in upper limb angiography of 0.25mS, which lies well below the UK-DRL limit (7 mSv) and far under European extremity CTA DRLs (100 mSv). This low ED was at the lower end of the reported ranges, underscoring the effectiveness of our protocol.

By optimizing imaging protocols, utilizing advanced technologies, and enhancing clinician awareness of radiation safety, it is possible to improve patient outcomes and image quality while minimizing the potential risks associated with ionizing radiation by reducing dosage. In conclusion, our procedure-specific ED benchmarks offer a solid basis for ongoing quality improvement, improved governance of radiation safety by following As Low as Reasonably Achievable (ALARA), and informed conversations between patients and clinicians regarding the trade-offs between risks and benefits in vascular imaging.

REFERENCE

1. Iordache SD, Goldberg N, Paz L, et al. Radiation exposure from computed tomography of the upper limbs. Acta Orthop Belg. 2017 Dec 1;83(4):581-8.
2. Metaxas VI, Dimitroukas CP, Efthymiou FO, et al. Patient dose in CT angiography examinations: an institutional survey. Radiation Physics and Chemistry. 2022 Jun 1;195:110083.
3. Dave RB, Fleischmann D. Computed tomography angiography of the upper extremities. Radiologic Clinics. 2016 Jan 1;54(1):101-14.
4. Goldsweig AM, Abbott JD, Aronow HD. Physician and patient radiation exposure during endovascular procedures. Current treatment options in cardiovascular medicine. 2017 Feb;19:1-3.
5. Li X, Hirsch JA, Rehani MM, Yang K, Liu B. Effective dose assessment for patients undergoing contemporary fluoroscopically guided interventional procedures. American Journal of Roentgenology. 2020 Jan;214(1):158-70.
6. Rana BS, Kumar S, Ahuja CK, et al. Estimation of radiation exposure to the patients in diagnostic and therapeutic interventional procedures. Radiation Protection Dosimetry. 2018 Oct 1;181(3):290-300.
7. Binkert CA, Verdun FR, Zanetti M, et al. CT arthrography of the glenohumeral joint: CT fluoroscopy versus conventional CT and fluoroscopy—comparison of image-guidance techniques. Radiology. 2003 Oct;229(1):153-8.

8. Fisher DR, Fahey FH. Appropriate use of effective dose in radiation protection and risk assessment. Health physics. 2017 Aug 1;113(2):102-9.
9. Romanyukha A, Folio L, Lamart S, et al. Body size-specific effective dose conversion coefficients for CT scans. Radiation protection dosimetry. 2016 Dec 3;172(4):428-37.
10. Christner JA, Kofler JM, McCollough CH. Estimating effective dose for CT using dose–length product compared with using organ doses: consequences of adopting International Commission on Radiological Protection Publication 103 or dual-energy scanning. American Journal of Roentgenology. 2010 Apr;194(4):881-9.
11. Alhailiy A, Alkhybari E, Alshuhri M, et al. Proposing Multiregional Diagnostic Reference Levels for Common CT Angiography Examinations in Saudi Arabia. Diagnostics. 2024 Jul 15;14(14):1523.
12. UKHSA. UKHSA-RCE-1 Doses from computed tomography examinations in the UK (2019 review) https://www.gov.uk/government/publications/computed-tomography-ct-national-patient-dose-audits.
13. Pradhan A, Kadavigere R, Sukumar S: Establishing local diagnostic reference levels for CT angiography examinations. J Health Sci Med Res. 2025;43(1):1084.
14. Biswas, Debdut BA, Bible, et al. Radiation Exposure from Musculoskeletal Computerized Tomographic Scans. The Journal of Bone & Joint Surgery 91(8):p 1882-1889, August 01, 2009.
15. Lalone EA, Fox AM, Kedgley AE et al. The effect of CT dose on glenohumeral joint congruency measurements using 3D reconstructed patient-specific bone models. Physics in Medicine & Biology. 2011 Sep 23;56(20):6615.
16. Boothe EK, Tenorio LL, Zabak EM, et al. Radiation dose reduction initiative: Effect on image quality in shoulder CT imaging. *Eur J Radiol*. 2017;95:118-123.