Iranian Journal of Medical Physics

ijmp.mums.ac.ir

Comparing IDREAM as an Iterative Reconstruction Algorithm against In Filtered Back Projection in Computed Tomography

Islam Kamal Abdel Fattah Maamoun [1*]

1. Medical Physics Department Department, Kundiawa Genera Hospital,Kundiawa ,Papua New Guinea Kundiawa, Papua New Guinea

ARTICLE INFO

Article type:
Original Article

Article history:
Received: Jul 17, 2019
Accepted: Sep 22, 2019

Keywords:
Computed Tomography
FBP
IDREAM
Image Noise
Image Quality
Iterative Algorithm SNR

ABSTRACT

Introduction: Recent studies of Computed Tomography (CT) conducted on patient dose reduction have recommended using an iterative reconstruction algorithm and mA (mili-Ampere) dose modulation. The current study aimed to evaluate Iterative Dose Reduction Algorithm (IDREAM) as an iterative reconstruction algorithm.

Material and Methods: Two CT protocols (i.e., A: 120 KV /150 mA, FBP; B: 120KV/ (20-150) mAs, IDREAM) to scan water and acrylic phantoms. A number of 40 patients were assigned to two CT protocols (C: n=20, 120KV/160 ±10 mAs, FBP and D: n=20, 120 KV/ (30-150 mAs, IDREAM), the two groups (C and D) were then referred to abdomen and pelvis CT scan (Sinovision, insitum 16) with contrast. Image quality parameters, dose calculations were measured for all groups (i.e., A, B, C, and D).

Results: Group B had a highly significant SNR with less significant noise ($P<0.05$), in comparison with group A. In addition, uniformity was markedly higher for group B ($P<0.05$) in water phantom and insignificantly different ($P>0.05$) in acrylic phantom, as compared to group A. CTDIvol (A: 13.94 mGy ; B: 6.91 mGy , $P<0.05$) and DLP (A:501.76 mGy.cm ; B :248.88 mGy.cm). Noise and SNR were significantly different ($P<0.05$) in group D against C. CTDIvol (C: 30.3±5.2 mGy ; D : 15.4 ±2.7 mGy, $P<0.05$), DLP (C:544±100 mGy.cm; D :272.3±50.3 mGy.cm ,$P<0.05$) and the effective dose (C:8.1±1.5 mSv; D :4.08±0.75 mSv,$P<0.05$)

Conclusion: The results of the present study were indicative of the feasibility of IDREAMas an iterative reconstruction algorithm.

► *Please cite this article as:*
Maamoun I. Comparing IDREAM as an Iterative Reconstruction Algorithm against In Filtered Back Projection in Computed Tomography. Iran J Med Phys 2020; 17: 170-174. 10.22038/ijmp.2019.41872.1613.

Introduction

Computed tomography (CT) is a major contributor to radiation dose among all imaging modalities. International atomic energy agency (IAEA) recommend that dose reduction techniques be emplemented to lower the patient radiation dose while preserving diagnostic quality.

The iterative reconstruction algorithm (IR) in CT is developed with increasing computer power. Thereby, IR allows for dose reduction while maintaining the diagnostic image quality by reconstruction of low-noise image data from noisy reduced-dose CT acquisitions [1].

Dose modulation (x,y, and Z) has been used in different CT vendors with an iterative reconstruction algorithm. CT manufacturers are competing for the best iterative algorithm to reduce image noise resulting from dose modulation technique. To determine dose reduction and image quality, different iterative algorithms were compared to generic filtered back projection (FBP) algorithm. The studies of Adaptive iterative dose reduction 3-dimensional (AIDR 3D) reduction in radiation dose and contrast content while preserving diagnostic performance[2],and An Evaluation of Sinogram Affir med Iterative Reconstruction (SAFIRE) vs. Filtered Back Projection (FBP) indicated that increased IR strengths lead to lower pixel noise, lower noise variation, and improved noise contrast (CNR)[3].

Low-dose CT (LDCT) technique with adaptive statistical iterative reconstruction (ASIR) can minimize radiation dose while maintaining relatively high image quality in urinary stone disease diagnosis [4].

In addition, IR did not bring any additional benefit to image quality for the identification of CT paranasal sinus structures and blinded reviewers unanimously agreed that scans obtained at 100 mA and 120 mA were appropriate for IR-independent surgery[5].

Iterative Dose Reduction Algorithm (IDREAM) is one of the iterative reconstruction algorithm designed by SINOVISION CT company. The current study aimed to compare IDREAM to standard reconstruction algorithm (FBP) in CT dose reduction and image quality.

Materials and Methods

Phantom Study

Water (W) and acrylic (A) phantoms were used as models with different density and contour (Figure 1) to

**Corresponding Author:* Tel: +201092006709; E-mail: islam_ptj@yahoo.com

represent different densities and thicknesses of the human body.This model is important to activate dose modulation technique of CT acquisition.

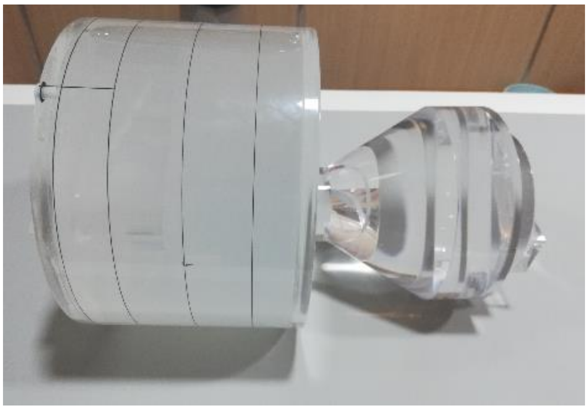

Figure 1.Water (circular) and acrylic (Cone) phantoms in a position of the scanning. The model is scanned by two different CT(Sinovision ,Instium 16) protocols (A and B) where (A: 120 KV /150 mA, FBP ; B: 120KV/ (20-150 mAs, IDREAM).

Image Quality Assessment

The uniformity (U), Noise (N), and Signal to Noise ratio (SNR) were measured for W and A phantoms in both A and B groups through drawing five equal-size region of interest ROI (Area=349 mm^2) at diferent locations of phantom (Figure 2) , followed by the application of the subsequent equations [6,7] :

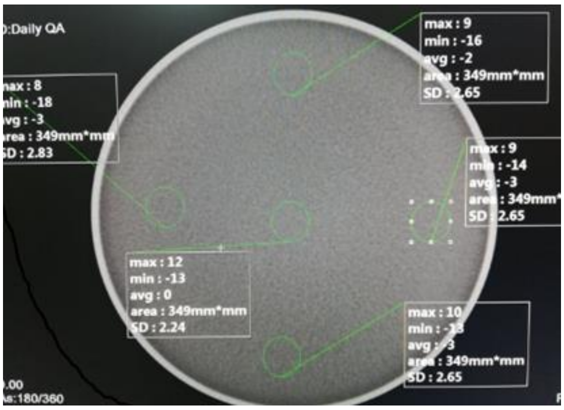

Figure 2 . Image quality assessment for CT water phantom

$$U = \frac{Umax - Umin}{Umax + Umin} \quad (1)$$

- U is an abbreviation of uniformity.
- U_{max} is an average maximum count (Hounsfield unit (HU)).
- U_{min} is an average minimum count (HU).

While the noise (N) is estimated by :

$N = \pm\sigma$ (2)

$SNR = N/\sigma$ (3)

Where N is the average haunsfield unit (HU) and σ is the average standard deviations.

Radiation Dose Calculations

CT dose index (CTDIvol) and dose length product (DLP) were estimated for (A&B) by the scanner using the following equations [7]:

CTDIvol = CTDIw/Pitch (4)

Where CTDIw is a weighted average of center and peripheral CTDI100 to arrive at a single descriptor.

DLP=CTDIvol × length of scan (in mGy*cm) (5)

The image quality parameters (U and N) and dose calculations (CTDIvol and DLP) were statistically studied for group A against group B.

Patient Study

A number of 40 patients (weight=80 ±15 Kg, Age =60 ±12 Y) were referred to abdomen and pelvis CT scan (Sinovision, Inistium 16, China) with contrast. The selected patients were assigned to two CT (Sinovision, Inistium 16) acquisition protocols (C: n=20, 120KV/160 ±10 mAs, FBP) and (D: n=20, 120 KV/ (30-150) mAs, IDREAM).

Image Quality Assessment for C and D groups

Three ROIs were drawn (Figure 3) on different segments of the liver (left, middle, and right lobes) (Area =63mm^2) to calculate the noise index (σ) and SNR.

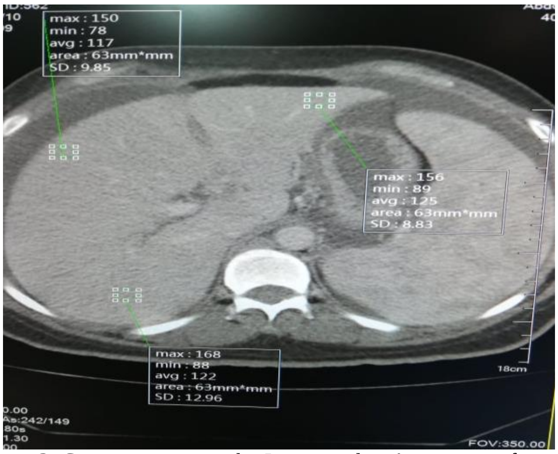

Figure 3. Computer tomography Image quality Assessment of patient liver depicting three ROIs (Area=63mm^2) drawn on liver segments

Radiation Dose Calculations

While the effective dose was calculated using 0.015 as a conversion factor [8], patient dose calculations (CTDIvol and DLP) were collected for C and D groups from summary dose reports.

All image quality parameters and patients dose results were statistically examined for group C versus group D and the obtained data were analyzed in SPSS software (version 16).

Results

The statistical analysis of water phantom results revealed a significant difference ($P<0.05$) between groups A and B in terms of noise, uniformity, and SNR as depicted in figures 4, 5, and 6 respectively. In this regard, group B has less significant values for noise and uniformity, as compared to group A, while SNR is highly significant in group B against group A.

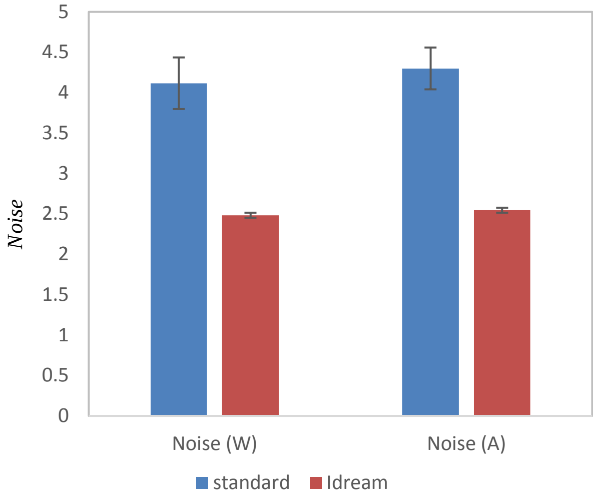

Figure 4. Noise values (Mean ±SD) between groups A (standard) and B (IDREAM) for water (W) and acrylic (A) Phantoms

For acrylic phantom, the SNR was significantly higher (P<0.05) in group B (IDREAM), as compared to group A (Standard); however, the uniformity was insignificant between the two groups (A and B; Figure 5).

The dose calculation parameters are higher significant in group A (CTDIvol=13.94 mGy and DLP=501.76 mGy.cm), in comparison with group B (CTDIvol=6.91 mGy and DLP=248.88 mGy.cm).

Patient data analysis was suggestive of noise and SNR significant difference in group C, as compared to group D with a P-value less than 0.05, as illustrated in Figure 7.

Patient dose calculations (CTDIvol, DLP, and effective dose) were significantly (P<0.05) less in group D, in comparison with group C, as demonstrated in Table 1.

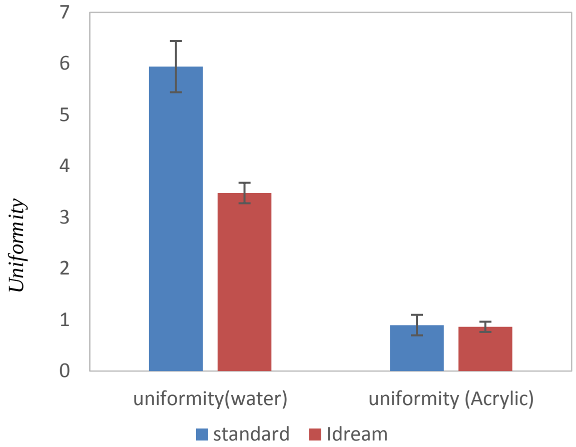

Figure 5. Uniformity values (Mean ±SD) between groups A (standard) and B (IDREAM) for water (W) and acrylic (A) Phantoms

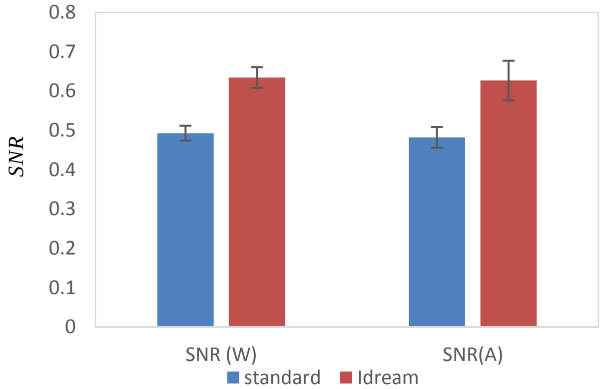

Figure 6. SNR values (Mean ±SD) between groups A (standard) and B (IDREAM) for water (W) and acrylic (A) Phantoms

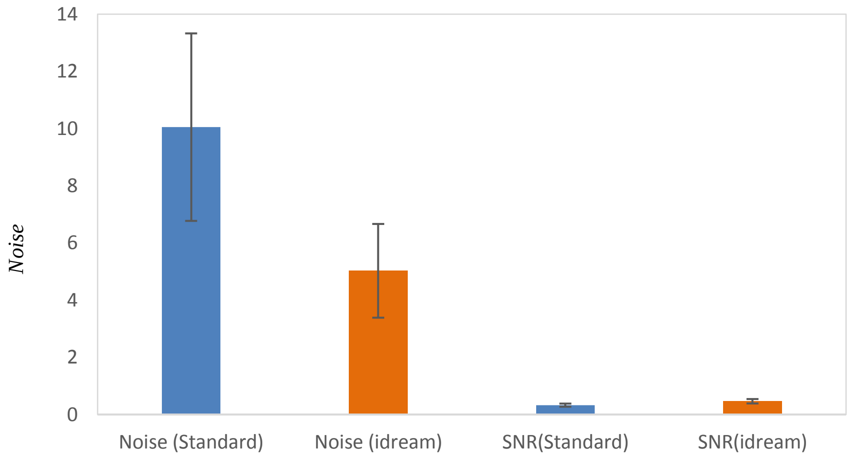

Figure 7. SNR and noise values (Mean ±SD) between groups C (standard) and D (IDREAM)

Table 1. CTDIvol , DLP, and Effective dose of group C (standard) against D (IDREAM)

Group	CTDIvol (mGy)	DLP (mGy.cm)	Effective dose (mSv)
Group C (standard)	30.3±5.2	544.6±100.7	8.1±1.5
Group D (IDREAM)	15.45±2.77	272.3±50.3	4.08±0.7

Discussion

Although CT scan is considered one of the most important medical advances of the past century, it carries its own hazards and complications. Just in the United States, an annual number of 29,000 new cancers are attributed to the past CT scans [9]. Among all CT scans, the abdominal and pelvic examinations are reported to transmit the highest radiation dose to the patients [10]; therefore, radiology community has been trying to get the best method for patient dose reduction while preserving the diagnostic efficiency [11]. In this regard, the recently introduced iterative reconstruction algorithm is one of the best innovations for patient dose reduction [12, 13].

Sinovision CT scanner presented IDREAM as an iterative reconstruction algorithm. Therefore, the current study is a quantitative assessment of IDREAM efficiency as a new iterative algorithm.

Our phantoms (water and acrylic) data results were indicative of a significant decrease in the noise (figure 4) with the implementation of IDREAM, as compared to standard reconstruction algorithm and this noise reduction, in turn, enhances SNR and uniformity in IDREAM group (B) (figure 5, 6). Despite the application of dose modulation for group B, IDREAM reduced the generated noise by 40% and 41% for water and acrylic phantom, respectively. This reduction of image noise decreases the variation of pixels values which results in a highly uniform image [14]. It is indispensable to assess the patient's image in order to confirm the IDREAM efficiency; therefore, the three segments of the liver are quantitively measured to get an average value of noise and SNR. The current study revealed noise reduction and high SNR in group D (IDREAM), in comparison with group C (standard).

The Dose modulation (Auto mA) has been implemented for group D (IDREAM) against group C (standard) which led to the reduction of patient's effective dose by 50 %. The variation of mA with the body (contour and density) plays a major role in dose reduction and noise level preservation [15].

The results of the present study were in line with the study conducted by Grosser et al. [16] who indicated that adaptive Statistical Iterative Reconstruction [ASIR] improved CT image quality for low-dose CT (LD-CT) in high-end hybrid imaging systems. The current research has three major limitations that should be addressed in future research. These limitations include patient weight within the range of 80±15 kg, IDREAM examination only on CT scan of the abdomen and pelvis, and the absence of previous research conducted on IDREAM.

Conclusion

The results of the current study were indicative of the feasibility of IDREAM as a new iterative algorithm with mA dose modulation CT acquisition protocols.

Acknowledgment

Our sincere appreciation and thanks go to Kundiawa General Hospital team for their valuable support during this research project.

References

1. Stiller W. Basics of iterative reconstruction methods in computed tomography: A vendor-independent overview, Eur J Radiol. 2018; 109:147-54. DOI: 10.1016/j.ejrad.2018.10.025.
2. Nakamoto A, Yamamoto K, Sakane M, Nakai G, Higashiyama A, Juri H, et al. Reduction of the radiation dose and the amount of contrast material in hepatic dynamic CT using low tube voltage and adaptive iterative dose reduction 3-dimensional. Medicine. 2018 Aug; 97(34). DOI: 10.1097/MD.0000000000011857.
3. Harris MA, Huckle J, Anthony D, Charnock P. The acceptability of iterative reconstruction algorithms in head CT: an assessment of sinogram affirmed iterative reconstruction (SAFIRE) vs. filtered back projection (FBP) using phantoms. Journal of medical imaging and radiation sciences. 2017; 48(3):259-69.
4. Li X, Shu H, Zhang Y, Li X, Song J, Du J, et al. Low-dose CT with adaptive statistical iterative reconstruction for evaluation of urinary stone. Oncotarget. 2018 Apr 13;9(28):20103. DOI:10.18632/oncotarget.25047.
5. Kimple AJ, McClurg SW, Huang BY, Sreenath SB, McClintock BW, Tomoum M, et al. Image quality and dose reduction in sinus computed tomography using iterative reconstruction: a cadaver study. Rhinology online. 2018;1:45. DOI:10.4193/RHINOL/18.015.
6. Nowik P, Bujila R, Poludniowski G, Fransson A. Quality control of CT systems by automated monitoring of key performance indicators: a two-year study. Journal of applied clinical medical physics. 2015;16(4):254-65.
7. A Task Group of the Nuclear Medicine Committee. Computer-Aided Scintillation Camera Acceptance Testing: American Institute of Physics. AAPM Report. 1982(091982).
8. McNitt-Gray M, DABR F. Assessing radiation dose: how to do it right. AAPM CT dose summit, Denver. 2011.
9. Schindera ST, Diedrichsen L, Müller HC, Rusch O, Marin D, Schmidt B, et al. Iterative reconstruction algorithm for abdominal multidetector CT at different tube voltages: assessment of diagnostic accuracy, image quality, and radiation dose in a phantom study. Radiology. 2011;260(2):454-62.

10. Smith-Bindman R, Wang Y, Chu P, Chung R, Einstein AJ, Balcombe J, et al. International variation in radiation dose for computed tomography examinations: prospective cohort study. Bmj. 2019;364.
11. Ferrero A, Takahashi N, Vrtiska TJ, Krambeck AE, Lieske JC, McCollough CH. Understanding, justifying, and optimizing radiation exposure for CT imaging in nephrourology. Nature Reviews Urology. 2019;16(4):231-44.
12. Silva AC, Lawder HJ, Hara A, Kujak J, Pavlicek W. Innovations in CT dose reduction strategy: application of the adaptive statistical iterative reconstruction algorithm. American Journal of Roentgenology. 2010;194(1):191-9.
13. Grosser OS, Ruf J, Kupitz D, Czuczwara D, Loewenthal D, Thormann Met al. Iterative CT reconstruction in abdominal low-dose CT used for hybrid SPECT-CT applications: effect on image quality, image noise, detectability, and reader's confidence. Acta radiologica open. 2019 ;8(6):2058460119856266. DOI:10.1177/2058460119856266.
14. Chen GP, Noid G, Tai A, Liu F, Lawton C, Erickson B, et al. Improving CT quality with optimized image parameters for radiation treatment planning and delivery guidance. Physics and Imaging in Radiation Oncology. 2017;4:6-11.
15. Pauchard B, Higashigaito K, Lamri-Senouci A, Knebel JF, Berthold D, Verdun FR, et al. Iterative reconstructions in reduced-dose CT: which type ensures diagnostic image quality in young oncology patients?. Academic radiology. 2017;24(9):1114-24.
16. Grosser OS, Ruf J, Kupitz D, Czuczwara D, Loewenthal D, Thormann M, et al. Iterative CT reconstruction in abdominal low-dose CT used for hybrid SPECT-CT applications: effect on image quality, image noise, detectability, and reader's confidence. Acta radiologica open. 2019 ;8(6):2058460119856266. DOI: 10.1177/2058460119856266.