Prevalence and Patterns of Computed Tomography Image Artefacts in a Radio-Diagnostic Centre in Anambara State of Nigeria

Original Article

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ABSTRACT

Background: Artefacts are a common occurrence in Computed Tomography (CT) imaging which obscure or simulate pathology. They often contribute to the degradation of the images produced hence the need to eliminate or reduce them to the barest minimum.

Objective: The objective of the study was to determine the prevalence and patterns of artefacts encountered during computed tomography examinations.

Methods: A cross-sectional study design was adopted for the evaluation of CT image artefacts. Images generated during computed tomography examinations were analyzed for the presence of artefacts.

Results: A total of 350 images were analyzed for the presence of artefacts. The result showed that 62.6% (219) of the images had artefacts while 37.4% (131) of the images had no artefact. Four types of artefacts were identified with 93 images (26.6%) showing motion artefacts, 81 images (23.1%) had streak artefacts, 5 images (1.4%) had photon starvation artefacts, while 2 images (0.6%) had ring artefacts. Some images had a combination of two artefacts with motion and streak artefacts occurring in 29 images (8.3%). Motion and ring artefacts occurred in 2 images (0.6%), motion and photon starvation artefacts occurred in 2 images (0.6%) while streak and photon starvation artefacts occurred in 1 image (0.3%).

Conclusion: Computed Tomography images had a high prevalence of artefacts with motion artefact as the most common artefact. Some design features should be incorporated into modern Computed Tomography scanners to minimize the appearance of artefacts or protocol optimization and advanced reconstruction techniques should be utilized to mitigate artefact-related image degradation.

Key words: Computed Tomography, Prevalence, Imaging, Artefacts

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Introduction

Computed tomography (CT) is a medical imaging modality that uses x-rays and computer technology to produce detailed cross-sectional images of the body [1]. It is based on the fundamental principle that the density of tissue passed by the x-ray beam can be measured from the calculation of the attenuation coefficient. So, CT permits the reconstruction of the density of the body and the cross-sections are reconstructed from the measurements of attenuation coefficients of x-ray beams in the volume of the object studied. Computed Tomography imaging has become an indispensable tool in modern medicine, providing high-resolution cross-sectional images of the human body that enable accurate diagnosis and treatment planning [2]

The use of Computed Tomography (CT) has increased rapidly since its inception and has revolutionized diagnostic radiology though the images are not without artefacts. In CT, an artefact refers to any discrepancy or distortion in the reconstructed image that does not accurately represent the anatomy or pathology being imaged [2] . Artefacts could also be systematic discrepancies between the CT number in the reconstructed image and the true attenuation coefficients of the object [3]. Computed Tomography images are inherently more prone to artefacts than conventional radiographs because the image is reconstructed from something of the order of a million independent detector measurements. This reconstruction technique assumes that all these measurements are consistent, so any error of measurement will usually reflect itself as an error in the reconstructed image. The artefacts contribute to image degradation and can lead to inaccurate or false diagnosis which can impact patient outcomes and treatment planning [4]. These artefacts could arise from various sources like patient related factors (motion), technical factors (beam hardening) and scanner related factors (calibration issues) [5]. Design features incorporated into modern scanners minimize some types of artefacts, while some can be partially corrected by the scanner software [3].

There are however, many instances where careful patient positioning and the optimum selection of scan parameters helped in reducing CT image artefacts. Studies done in the past have reported varying prevalence rates of CT image artefacts ranging from 15% to 90%, depending on the type of artefact, scanner technology and patient population [5,6]. The studies carried out by Alzain et al [7] and Adejoh et al [8] on CT artefacts, found out that motion artefact was the most common artefact in Computed Tomography. Veikutis et al (9) however in their study discovered that beam hardening artefact was the most common artefact encountered during CT followed by motion artefact.

Despite advances in CT technology, artefacts remain a significant challenge in clinical practice. In view of the fact that artefacts obscure and simulate pathologies, it is important to determine the types of artefacts, the frequency of artefacts in CT images and the parts of the body where these artefacts occur. The aim of the study is to determine the prevalence and patterns of artefacts in Computed Tomography in a radio-diagnostic facility in Anambra State, Nigeria.

Materials and Methods

A cross-sectional study design was adopted for this study and was conducted in a selected radio-diagnostic facility with computed tomography scanner in Anambra State, Nigeria. The instruments for data collection include; Siemens 16 Slice CT scanner, data capture sheet, phone camera and pen.

All head, chest, abdominal and other body parts CT images acquired from January 2021 to December 2024 with all necessary information such as age, gender, present and absent of artefacts were considered as the study sample size, which are 350 images. These images were selected using a convenience sampling technique.

The ethical approval for this study was obtained from the research ethical committee of the faculty of Health Sciences and Technology, Nnamdi Azikiwe University, Anambra State and the purpose of the study was adequately explained to the management of the study centre. Every information obtained was held in strict confidence and not disclosed to any other person except for the purpose of the research. No information that revealed the identity of the patients was included in this study.

PROCEDURES FOR DATA COLLECTION

Head CT

Patients were prepared for the investigation, first by removing all dentures, jewelries or metals on the head and neck region and procedures were also explained to the patients to gain their maximum cooperation. All head CT examinations were performed with the patients lying supine on the couch, with hands by the side of the trunk and head of the head rest. The head was immobilized using radiolucent foam pads. The main scan was planned on the lateral scan radiograph also known as scout image with the start location at the radiographic baseline and end location above the vertex of the skull. The exposure factors varies depending the size of the individual but the common factors include; 120 kVp, 250 mA, 1 second gantry rotation time, slice thickness of 5mm, slice interval of 5mm, standard algorithm, scan field of view (SFOV) of 25cm. In some situations, contrast media were administered to the patients depending on their clinical indications.

Chest CT

The chest CT examinations were done with the patients lying supine on the couch, with hands raised above the head. The immobilization of the patient was done using straps. The main scan was planned on the anterioposterior scan radiograph also known as scout image. The exposure factors varies depending the size of the patient but the common factors include; 120 kVp, 250 mA, 1 second gantry rotation time, Slice thickness of 3mm, slice interval of 3mm, standard algorithm, scan field of view(SFOV) of 48cm, display field of view (DFOV) of 15cm, window with (WW) of 500 and window level (WL) of 60. In some situations, contrast media were administered to the patients depending on their clinical indications.

The CT images were retrieved from the digital image archive and data such as age, gender, types of CT investigation, body parts and types of artefacts were documented by the researchers using data capture sheet designed to achieve the aim of this study.

METHOD OF DATA ANALYSIS

The obtained data were analyzed with the Statistical Package for Social Sciences (SPSS) version 21 using both descriptive (table, bar charts, frequency and percentages) and inferential (Chi-Square test) statistical tools. The descriptive statistical tools were used to analyze the demographic variables, the prevalence of the artefacts, types of body and the types of the artefacts while the Chi-Square was used to test for associations between types of artefacts and demographic variables such as age and gender. A p-value < 0.05 was chosen for statistical significance.

Results

Out of 350 CT images included in this study, 64 % (n = 224) were that of males while females' images accounted for 36% (n = 126) as shown in Figure I. The majority 28.1% (n = 99) of the CT images were of those within the age group of 41- 60 years of age followed 25.1% (n=88) of age 21-40 years and the least 3.7% (n=13) were that of those within age group > 80 years (Figure 2). Head CT images was highest 70.6 % (n=247), followed by abdominal CT images 17.4 % (n=61) and the least 0.6%(n=2) was shoulder CT (Table1). Out of 350 CT images, the majority 62.6 %(n=219) had artefacts while 37.4% (n=131) had no artefacts (Table 2).

Motion artefacts was highest 42.5 % (n=93), followed by streaks artefacts 37% (n=81) and the least 0.5% (n=1) was streaks and photon starvation artifact (Table 3). There was a statistically significant association between types of body parts and artefacts at (p=0.00, df=4 and χ^2=24.956) (Table 4). There was also a statistically significant association between patterns of artefacts and age group at (p=0.00, df=36 and χ^2=80.473) but there was no statistically significant association between patterns of artefacts and age group at (p=0.476, df=9 and χ^2=8.591) (Table 5).

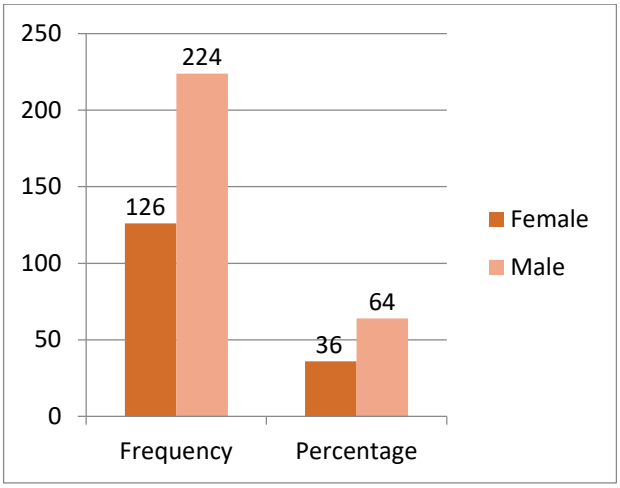

Fig 1: Bar chart of frequency & % distributions of gender

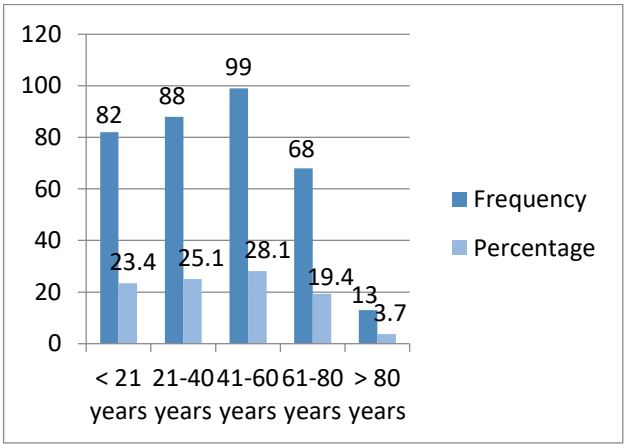

Fig 2: *Showing Bar chart of Age group*

Table 1: Showing the frequency distribution of the various types of body parts

Body parts	Frequency	Percentage
Shoulder CT	2	0.6
Lumbar spine CT	4	1.1
Neck CT	4	1.1
Pelvic CT	6	1.7
Chest CT	26	7.5
Abdominal CT	61	17.4
Head CT	247	70.6
Total	350	100.0

Table 2: Showing prevalence of artefacts in CT images

No Examined	No of images with artefacts	No of images without artefacts	Prevalence of CT artefacts
350 (100%)	219 (62.6%)	131 (37.4%)	219 (62.6%)

Table 3: Showing the patterns of CT images artefacts

Patterns	Freq	%
Metallic Streaks	4	1.8
Motion	93	42.5
Motion and Photon Streaks	2	0.9
Motion and Ring	2	0.9
Motion and Streaks	29	13.2
Photon Starvation	5	2.3
Ring	2	0.9
Streaks	81	37.0
Streaks and Photon Starvation	1	0.5
Total	**219**	**100.0**

Table 4: Chi-Square table showing association between types of body parts and artefacts

Variable	χ^2	Df	*P*-value	Remark
Types of body parts * CT image Artefacts	24.956	6	0.00	Sig

Table 5: Chi-Square table showing association between patterns of the artefacts and demographic variables (Age and Gender)

Variables	χ^2	Df	*P*-value	Remark
Age	80.473	36	0.00	Sig
Gender	8.591	9	0.476	N/S

Discussion

The finding of this study shows that males were the highest in terms of CT investigations, which could be attributed to the nature of jobs done by men, which include but not limited to brick laying, carpentering and other craftsmanship that exposes them to numerous health challenges. Greater numbers of the CT images were that of young adults in the fourth and fifth decade of life. This may due to the fact that these category of people account for the major workforce in any society and may be exposed to conditions that may predisposes them to medical health conditions involving undergoing CT investigations[10].

We identified high prevalence of artefacts in CT procedures in the study setting and this may be ascribed to multi-factorial causes ranging from age, patient condition, operator's, CT scanner detector efficiency and type of the investigation. In this study, three types of artefacts were documented but the most common type was motion artefact. This finding is consistent with the findings of the studies conducted by Alzain et al [7] and Adejoh et al [8].

In Alzain et al [7] study on the common computed tomography artefacts, also reported that the most common encountered in CT department is the motion artifact in brain CT and the best method to reduce it was adequate patient preparation. Also Adejoh [8] in their study to evaluate the artefacts in computed tomography of the head, at Nnamdi Azikiwe University Teaching Hospital, stated that motion artefacts had the highest frequency of occurrence in computed tomography. However, the result of this finding is inconsistent with the findings of Veikutis et al [9] on artefacts in computed tomography imaging in Lithuanian University of health sciences, Kuanas clinical hospital, where the most common type of artefact was beam hardening artefact. The differences in our findings could be ascribed to the cooperation of the patients in the research location, as well as their health status and age, as some age groups like the geriatrics and paediatrics are more prone to positioning instability during CT examinations. In addition, the differences in our sample size could also be responsible for the variations in our results.

Most of the artefacts were found in head CT images followed by abdominal, Chest CT, pelvic, lumbar spine CT and neck CT. This indicates that head CT has the highest number of artefacts in computed tomography and this also indication that head CT could be the most commonly performed CT investigation when compared to the other body parts. This is in keeping with the findings of the study conducted by Adejoh et. al, in 2015 where they concluded that brain CT was the most frequent CT investigation and it accounted for the highest number of artefacts [8].

There was a statistically significant association between types of body parts and artefacts. These imply that the possibility of artefacts to occur in CT investigations is strongly influenced by the types of body part examination. This is why head CT artefacts are common when compared with that of other body parts. There was also a statistically significance association between patterns of artefacts and age group but there was no statistically significant association between patterns of artefacts and gender. These imply that age of the individual has significant impact on the occurrence of CT image artefacts across the various body parts. This may also be a proof that CT image artefacts are more common among children than adults since children find it difficult to adhere to instructions during the investigation. The nature of CT image artefacts is independent of the gender of the individual. Computed tomography image artefacts can occur in male and female at different degree without the gender status having any influence on it.

CONCLUSION

Computed tomography images had a high prevalence of artefacts with motion artefact as the most common artefact. There was statistically significant association between patterns of artefacts and age group but no statistically significant association between patterns of artefacts and gender was found. Radiographers should ensure adequate patients' immobilization especially for children and uncooperative ones. Also adequate instructions should be given to patients especially the conscious and adult patients.

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