Analysis of Artefacts from Computed Tomography of the Head at Nnamdi Azikiwe University Teaching Hospital, Nnewi

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ABSTRACT

Background: Artefacts are commonly encountered in clinical Computed Tomography (CT), and may degrade the quality of the image and obscure or simulate pathology leading to mis-diagnoses.

Objective: To identify the type and frequency of artifacts in Computed Tomography examinations performed at Nnamdi Azikiwe Teaching Hospital.

Methodology: A retrospective study carried out in February and March 2016, involving the visual analyses of 377 digital images generated in 2015, to exclude and categorize artefacts identified.

Results: Three hundred and seventy-seven (377) images were generated with 171 (45%) showing evidence of artefacts. Head request was the most frequent examination (n = 335) and yielded the highest number of artefacts (n = 162). Both male (49%) and female (40%) had comparable number of images with artefacts . Motion (n = 99) had the highest and lowest frequency respectively.

Conclusion: Forty-five percent (45 %) of images (n = 171) at the centre had artefacts with five distinct types isolated. Artefacts can be minimized if regular quality control is carried out.

Keywords: Computed tomography, artefacts, streaks, motion

INTRODUCTION

An imaging modality can be characterized by its spatial contrast and temporal resolutions. The capabilities of computed tomography (CT) to other imaging modalities can be understood in these terms [1]. Computed tomography has become a valuable tool in medicine, industry, archaeology and other fields. Therefore, various types of CT artefacts will need to be effectively removed in order not to compromise resolutions [2, 3].

An image artefact is a visualized structure in the reconstructed data that is not present in the object under investigation [4]. In CT, the term is applied to any systematic discrepancy between the CT numbers in the reconstructed image and the true attenuation coefficients of the object [5].

Artefacts are commonly encountered in clinical Computed Tomography (CT), and may obscure or simulate pathology [6]. They also degrade the quality of the image tremendously, often obscuring valuable details and detracting from its usability [7]. There are many different types of CT artifacts, including noise, beam hardening, scatter, pseudo enhancement, motion, cone beam, helical, ring and metal artifacts [6].

Many sources can be the origin of CT artefacts. Most artefacts can be prevented by using new designs in scanner technology, by careful positioning of patients during scanning, and by optimum selection of scanner parameters (pitch, filter kind and delivered energy). Some others can be reduced by addressing the problem in software developments. Most artefacts appear as streak effects in CT images and some of the causes are metallic objects, beam hardening, photon starvation and motion [8].

It is also possible to group the origins of these artefacts into four categories: (a) physics-based artefacts, which result from the physical processes involved in the acquisition of CT data; (b) patient-based artefacts, which are caused by such factors as patient movement or the presence of metallic materials in or on the patient; (c) scanner-based artifacts, which result from imperfections in scanner function; and (d) helical and multisection artefacts, which are produced by the image reconstruction process [5].

Poor knowledge of the types and origin of artefacts encountered in clinical practice might lead to repeat investigations with the attendant radiation risks. Also, patients wait for longer hours and waste valuable man hours in the hospital. There is also more stress imposed on the machine as well as on the radiographers themselves. In the centre in focus, since the installation of a CT scanner in 2011, hundreds of CT investigations had been carried out. However, no study is known to have been done to analyze the images for artefacts. This study was therefore, planned to address that issue.

MATERIALS AND METHODS

The design of the study was retrospective and it was carried out at the Nnamdi Azikiwe University Teaching Hospital, Nnewi, Nigeria in February and March 2016. Ethical committee and departmental approvals to carry out the study were obtained. The population of digital images were those generated in 2015. The centre had a GE Brightspeed Excel scanner, manufactured in 2007 and installed in 2011, with a 4-slice per rotation capacity. The modality had self-calibrating software which was activated daily. Confidentiality was guaranteed by the activation of customized image anonymity feature which masked subject's digital information except date and protocol details (figures i-v). A total number of 377 CT images were generated within the study period. Statistical analyses were manually done to establish central tendencies. Results are presented in tables.

RESULTS

Three hundred and seventy-seven (377) images were generated with 171 (45 %) showing evidence of artefacts. Head exams had the highest frequency of images (n = 335) and artefacts (n = 162). Both male (49%) and female (40%) had comparable number of images with artefacts (Table 1). Motion artefact (n = 99) had the highest frequency while image noise/quantum mottle (n = 11) had the lowest frequency (Table 2). The images of specific artefacts are also given (Figure i-v).

Table 1: Regional distribution of CT investigation & artefacts within the study period

Anatomy	Male		Female		Total	
	Frequency of exams	Number with artefacts	Frequency of exams	Number with artefacts	Frequency of exams	Number with artefacts
Head	208	107	127	55	335	162
Cervical Spine	1	0	6	1	7	1
Chest	8	1	8	1	16	2
Abdomen	11	3	8	3	19	6
Total	228	111(49%)	149	60 (40%)	377	171 (45%)

Table 2: Specific Nature and Frequency of the Artefacts

Artefact	Cause	Description	Frequency
Motion	Due to patient, cardiac, respiratory, bowel movement [9]	Blurring, double images and shading as well as long range streaks [6]	99 (58%)
Photon Starvation	Increased photon mean energy due to absorption of lower energy photons by dense structures [5]	Dark streaks between two high attenuation objects, such as metal, bone, iodinated contrast [6]	25 (15%)
Streaks	Metals, dental fillings [6]	Streaks [10]	22 (13%)
Ring	Mis-calibrated or defective detector element [5]	a bright or dark ring centered on the center of rotation [6]	14(8%)
Noise	Due to the statistical error of low photon counts [6]	Randomly and/or non-randomly distributed disturbance of a signal that tends to obscure the signal's information content from the observer [11]	11 (6%)
Total			**171 (100%)**

Figure i: Normal head CT image (brain window)
Artefacts will change the homodense nature of the different tissues into a heterogenous density or expand the grains to become larger (noisier).

Figure ii: Motion artefacts.
The shades/bands are as a result of patient's head movement during slice acquisition.

Figure iii: Photon starvation artefacts.

The homodense nature of the brain tissue is converted into lines that appear grainy. It is as a result of excessive attenuation of the X-ray photons by the hyperdense teeth. A scan over the teeth will often result in photon starvation but the image remains diagnostically useful.

Figure iv: Ring artefacts

A virtual ring appears in the image. It is as a result of detector mis-calibration. Cold tube that was not warmed after prolonged idleness was the known cause of ring artefacts at the centre.

Figure v: Streaks

Artefacts arising from metals or dental fillings often appear as streaks radiating out from the source.

DISCUSSION

This work was designed to investigate the types of artefacts in CT images generated at Nnamdi Azikiwe University Teaching Hospital. Head examinations recorded the highest subject throughput (n=335;89%) as well as artefact yield (95%). A significant proportion of the images (45%) had artefacts with motion as the most common (58%).

More male than female subjects were examined at the centre. It was therefore logical to anticipate more artefacts from male subjects. However, when the frequency of both gender was normalized using percentage, both male (49%) and female (40%) had comparable levels of images with artefacts. Artefacts should therefore not be expected to have gender affinity.

Motion artefact was the major challenge at the centre (Table 2; Figure ii). Patient movement during CT scanning can be voluntary, such as the movement of the chest during inspiration and expiration, or involuntary such as cardiac motion. Severely injured patients or children frequently move during scanning, causing motion artifacts.

Careful patient positioning and optimum selection of scanning parameters are important factors in avoiding CT artefacts. However, some should be corrected by the scanner software [8].

Motion artefacts can also be corrected by proper instructions to patients and attentiveness during the procedure, to ensure that 'start scan' is activated only when the patient is immobile. Mentally alert patients who are aware that they are being watched through the protective glass window may be less adventurous in moving. In the centre in focus, irritable and restless paediatric subjects were sedated which grossly reduced motion artefacts.

The usual appearance of artefacts is in the form of streaks which may be random or regular (Figure v). In very heterogeneous cross sections, dark bands or streaks can appear between two dense objects in an image. They occur because the portion of the beam that passes through one of the objects at certain tube positions is hardened less than when it passes through both objects at other tube positions. This type of artefact can occur both in bony regions of the body and in scans where a contrast medium has been used [5].

The streaks seen in our analyses were mostly from the teeth when scan range was extended from the vertex to the mandible (figure v). Streaks from dental fillings were also noted though infrequently. This scenario presents some challenge to the radiographer as the dental fillings cannot be removed nor facial bones avoided in some trauma cases. The good news is that radiologists and surgeons understand these artefacts and can usually make their diagnoses irrespective of them.

CONCLUSION

Artefacts play an important role in diagnostic accuracy. Regular quality control of the CT scan protocols can reveal their presence. Adequate instructions to patients and attentiveness of the radiographer during scan are important factors in avoiding CT artefacts. Further analyses of CT artefacts in other centres are recommended to have a wider stock of knowledge.

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