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LOW DOSE COMPUTED TOMOGRAPHY SCAN IN PARANASAL SINUSITIS, IS IT SUFFICIENT?

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ABSTRACT

Background: Computed tomography (CT) has become a useful diagnostic modality in evaluation of the paranasal sinuses & an integral part of surgical planning. Because of the high inherent contrast in the paranasal sinuses and nasal cavity, a low-dose technique can be used. **Aim of study:** to compare anatomical diagnostic image value assessment of low dose and standard dose protocol of computed tomography scanning of paranasal sinuses based on subjective assessment. **Patients and methods:** A prospective study was done in Baghdad teaching hospital and X-Ray institute over a period of 11 months. A group of 100 patients referred from ear, nose and throat outpatient clinic with clinically suspected sinusitis were examined by low dose (milliampere second (mAs= 30) and standard dose (mAs=100) protocol sinus CT scan, each patient was examined in the same day, after obtaining their oral consent. The patient was examined in supine position using 64 slice multidetector computed tomography (MDCT). Scans were reviewed by three experienced radiologists independently to evaluate image quality and important anatomical structures, using both soft tissue and bone window algorithms. These criteria were scored and the scores were added together to achieve an overall quality rating. **Results:** According to image quality scoring & relevant anatomic landmarks scoring, all the findings and all the structures in both groups were well defined. On evaluating the mucosa of the paranasal sinuses, normal and pathologic mucosal structures were scored as very well defined in all of the patients. The interobserver agreement was excellent. **Conclusion**: Further reduction of tube current (mAs) in CT scanning of paranasal sinuses in uncomplicated sinusitis is thought to be possible without reduction in diagnostic quality of the images. The radiation dose has been reduced by 70% by using lose dose protocol.

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INTRODUCTION

Computed tomography scanning can be helpful in the diagnosis of acute and chronic sinusitis, neoplastic and inflammatory processes, and other problems (e.g. congenital anomalies) (Minni, 2012). An adult`s approximate effective radiation dose for CT of Head is 2 mSv comparable to natural background radiation for 8 months (ACR, 2018). The growing prevalence of patients complaining of sinus-like symptoms requiring diagnostic imaging has increased the awareness of potential hazards from radiation exposure (Hojreh, 2005). Because of the high inherent contrast in the paranasal sinuses and nasal cavity, a low-dose technique can be used (Adam, 2015). A numbers of radiation dose-reduction strategies have been successfully used for paranasal sinus CT (Perisinakis, 2005).

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Greater attention has been directed toward adjusting CT parameters, most commonly through the reduction of milliampere-second (mAs) (tube current time product), to allow reduced radiation exposure while maintaining acceptable image quality (Abul-Kasim, 2011). CT dose index (CTDI) is a standardized measure of radiation dose output of a CT scanner & It is important to remember that $CTDI_{vol}$ does not represent the actual or effective dose for the patient (Bashir, 2018). In spite of advances in manufacture of CT scanners & the development of many new software which clean up artifacts & clarify the image & makes it possible to obtain good image quality at much lower radiation dose than previously used, many imaging departments are still using old standard imaging protocols without appreciation of radiation dose reduction great yields (Hagtvedt, 2003). The rationale of our study is to adopt a low dose CT protocol with good image quality in addition to maintenance of patients' safety by reducing radiation exposure, especially to the lens & thyroid.

Aim of the study

To find out if the image quality of the low-dose protocol MDCT scanning of the paranasal sinuses has any significant difference to the image quality of standard-dose protocol based on subjective assessment, for the diagnosis and management of patient with sinusitis. Specifically, we compare the diagnostic image quality and the demarcation of the important and clinically relevant anatomical structures of the sinonasal cavities between the two scanning protocols.

PATIENTS AND METHODS

Settings and study design: This was a prospective study conducted from March 1, 2017 to January 31, 2018, 100 consecutive patients were referred by ENT surgeon who suspected to have sinusitis referred to radiology department in Baghdad Teaching hospital and X-Ray institute in the medical city in Baghdad for MDCT of sinonasal cavities. The patients were randomely selected & they underwent both low-dose MDCT and standard-dose MDCT of the sinonasal cavities.

Definition of the case

Inclusion criteria: include acute sinusitis, acute exacerbation of chronic sinusitis, patients who had been scheduled for preoperative assessment for functional endoscopic sinus surgery (FESS) and for further assessment of the paranasal sinuses (post-FESS) were also included in this study.

Exclusion criteria: includes patients younger than 18 years old as they are more radiosensitive and the paranasal sinuses reach full pneumatization by 18 years old. Patients with another paranasal sinuses pathology such as mass lesion as this is non – contrasted study and low dose scan may be less efficient with mass lesion.

Ethical consideration: The protocol of this study has been approved by the the scientific council of radiology / Arab board of Health Specializations in Iraq. All patients were given oral information including an explanation of examination steps and the every patient was informed that he/she will be examined two times, the first time examination done with standard dose and the second time examination will be done by a low dose which is about one third of the first one. All patients gave their informed consent.

Procedures

The patient advised to remove any radio-opaque materials from the head and neck region to avoid artifact which may compromise image quality. Then, scanning was done in the supine position. Non-contrast helical CT scanning was done using the 64-slice CT scanner (Philips brilliance 64 slice and Toshiba aquilion 64 slice) in axial sections including the area from the upper part of the frontal sinuses to the hard palate and from the anterior part of nose to the region behind the mastoid process. The scan was taken in a cranio-caudal manner in supine position. Each patient was scanned two times, first time using the standard protocol and then using the low-dose protocol. The KVp for both protocols was the same (KVp 120). All factors were the same in each exam with exception of mAs which was changed. It was (100) in the standard-dose protocol and (30) in the low-dose protocol both done in supine position. For every patient, images reconstructed in 0.9 mm from the raw data available. The reformatted axial and coronal images of the standard-dose and low-dose protocols of each patient were then independently evaluated by three experienced radiologists at different times. The readers were blinded to the mAs setting used. The images were viewed in bone window setting (window width of 2000 and window level of 200) and in the same viewing circumstances. Each radiologist (reviewer) review and score the images for one time only. The image quality was assessed and recorded in a special sheet based on the following imaging characteristics:

A: The diagnostic image quality assessed by:

- The complete opacification of one or more of the paranasal sinuses
- The presence of mucosal thickening
- The presence of air fluid level
- The presence of any bony abnormality (sclerosis, thickening or lysis)
- The presence of nasal septum deviation
- The presence of turbinate hypertrophy.

Each reviewer will give his own score as follows: (0) if the radiological finding is not found, (1) if the radiological finding is visualized but indeterminate and (2) if the radiological finding is clearly visualized. This score is validated by group of radiologists working in medical city & participated in the study.

B: The following important and clinically relevant anatomical structures of the sinonasal cavities assessed by:

- The maxillary sinuses
- The osteomeatal complex (which include the ethmoidal infundibulum, uncinate process, maxillary ostium, ostia of anterior and middle ethmoidal air cells and middle meatus)
- The frontal sinus
- The frontal recesses
- The anterior ethmoidal air cells (including the agger nasi cells-frontal anterior ethmoidal air cells)
- The posterior ethmoidal air cells
- The basal lamella (divides the anterior and posterior ethmoidal air cells)
- The sphenoethmoidal recess (including the ostium of the sphenoid sinus)
- The sphenoid sinus and septum
- The cribriform plate
- The lamina papyracea
- The pathway of right optic nerve (including its relation to the posterior ethmoidal air cells)
- The pathway of left optic nerve (including its relation to the posterior ethmoidal air cells)
- Right internal carotid arteries pathway in relation to the sphenoid sinus
- Left internal carotid arteries pathway in relation to the sphenoid sinus.

Again, each reviewer will decide if the appearance of the anatomic structures was normal, indeterminate or abnormal and give a score as follows: (0) If the structure is normal, (1) If the structure is indeterminate and (2) If the structure is abnormal. This score is validated by group of radiologists working in medical city & participated in the study.

Table 1. Wilcoxon test (Ranks)

Compared Related Samples (first variable/second variable)	Ranks Description	Number of patients	Mean Rank	Sum of Ranks
Rad1 diagnostic image quality low dose	-Negative Ranks	1	1.00	1.00
	-Positive Ranks	0	.00	.00
Rad1 diagnostic image quality standard dose	-Ties	99		
	-Total	100		
Rad1 anatomical structures low dose - Rad1 anatomical structures standard dose	-Negative Ranks	4	4.00	16.00
	-Positive Ranks	3	4.00	12.00
	-Ties	93		
	-Total	100		
Rad2diagnostic image quality low dose – Rad2diagnostic image quality standard dose	-Negative Ranks	2	1.50	3.00
	-Positive Ranks	0	.00	.00
	-Ties	98		
	-Total	100		
Rad2 anatomical structures low dose – Rad2 anatomical structures standard dose	-Negative Ranks	3	4.17	12.50
	-Positive Ranks	3	2.83	8.50
	-Ties	94		
	-Total	100		
Rad3 diagnostic image quality low dose – Rad3 diagnostic image quality standard dose	-Negative Ranks	1	3.50	3.50
	-Positive Ranks	3	2.17	6.50
	-Ties	96		
	-Total	100		
Rad3 anatomical structures low dose – Rad3 anatomical structures standard dose	-Negative Ranks	3	6.83	20.50
	-Positive Ranks	8	5.69	45.50
	-Ties	89		
	-Total	100		

*First variable is sum of scores for diagnostic image quality or anatomical structures using low dose CT
*Second variable is sum of scores for diagnostic image quality or anatomical structures using standard dose CT
*Negative Ranks are given when the first variable is less than the second variable
*Positive Ranks are given when the first variable is more than the second variable
*Ties are given when the first variable is equal to the second variable

After finishing this assessment, diagnostic image quality scores were added together to provide a collective quality rating. The minimum score for diagnostic image quality assessment will be (0) and maximum score will be (12). In the Same way, scores for the important and clinically relevant anatomical structures of the sinonasal cavities were added together to provide a collective quality rating and the minimum score will be (0) and the maximum score will be (30). Inter observer Variability Estimation of the coefficient of variance was done from the final total scores of the diagnostic image quality and important anatomical structures for both the standard-dose and low-dose protocols. The overall inter-observer variability was verified. Analysis of data performed with software windows Microsoft Excel 2000 and Statistical package for social sciences (SPSS) version 22.0 for comparison between the mean total scores from the low-dose protocol and the mean total scores from the standard dose protocol for each reviewer in both diagnostic image quality and important & clinically relevant anatomical structures assessment was done. The null hypothesis in this study was that there is no difference between the scores of these two protocols. Wilcoxon ranked test, a non-parametric statistical hypothesis test, was used as the test of significance and the p-value of less than (0.05) was considered statistically significant value. Our calculations were done at 95% confidence interval.

RESULTS

This study involved 100 patients contributed in the analysis, of them 55 (55%) were male and 45 (45%) were female. The patients' ages were between 18 to 61 years old with a mean age of 31 years & standard deviation of 10.553 Evaluation of image quality (Table 1), (Fig.1 & 2): According to the analysis of the overall total score of both protocols by the 1st reviewer (radiologist 1(rad1)), there was discrepancy in the score of one studied patient (1%).

For the second reviewer (radiologist 2(Rad2)), there were discrepancies in the score of two studied patients (2%). For third reviewer (radiologist 3(Rad3)), there were discrepancies in the score of four studied patients (4%). For all reviewers, the discrepancies were on the assessment of presence of mucosal thickening. Evaluation of anatomical structures (table 1): According to the analysis of the overall total score of both protocols by the first reviewer (rad1), discrepancies were seen in the scores of seven studied patients (7%). The differences were seen in the path of optic nerves, path of ICAs, the anterior ethmoid air cells and the frontal recess. Although these discrepancies were proven to be statistically not significant. For the second reviewer (Rad 2) there were discrepancies in the scores of six patients (6%), the differences are seen in spheno-ethmoidal recess, path of optic nerves and path of ICAs .These differences were statistically not significant as well. For the third reviewer (Rad 3) there were differences in the score of eleven patients (11%), the differences were seen in anterior ethmoidal air cell, posterior ethmoidal air cell, basal lamella, path of ICAs, sphenoethmoidal recess and sphenoid sinus &septum. However, these discrepancies were statistically not significant. Test statistics analysis:- By the analysis of test statistics table, we found that there was no statistically significant difference in the overall scoring system between standard dose protocol and low dose protocol CT scan of paranasal sinuses in assessment of diagnostic image quality and important anatomical structures for all three reviewers.(Table 1 continued).

Radiation dose analysis: When we compare volume CT dose index($CTDI_{vol}$), which is a standardized measure of radiation dose output of CT scanner and a common method to estimate a patient radiation exposure from a CT procedure, it was (12.77mGy) in standard dose CT scan & (3.83mGy) in low dose CT scan calculated automatically by the instrument. This means that when we reduce the mAs from (100) to (30), patient radiation exposure will be reduced by 70%.

Table 1. Wilcoxon test (continued) Test statistics

Significance	Rad1diagnostic image quality low dose- Rad1diagnostic image quality standard dose	Rad1anatomical structures low dose - Rad1anatomical structures standard dose	Rad2diagnostic image quality low dose – Rad2diagnostic image quality standard dose	Rad2anatomical structures low dose – Rad2anatomical structures standard dose	Rad3diagnostic image quality low dose – Rad3diagnostic image quality standard dose	Rad3anatomical structures low dose – Rad3anatomical structures standard dose
Z-score	-1.000[b]	-0.378[b]	-1.414[b]	-0.422[b]	-0.557[c]	-1.124[c]
P-value	0.317	0.705	0.157	0.673	0.577	0.261

a. Wilcoxon Signed Ranks Test
b. Based on positive ranks.
c. Based on negative ranks.
Z-score: indicate how many standard deviation an element from the mean.
P-value: smallest level of significance at which at which the null hypothesis would be rejected.

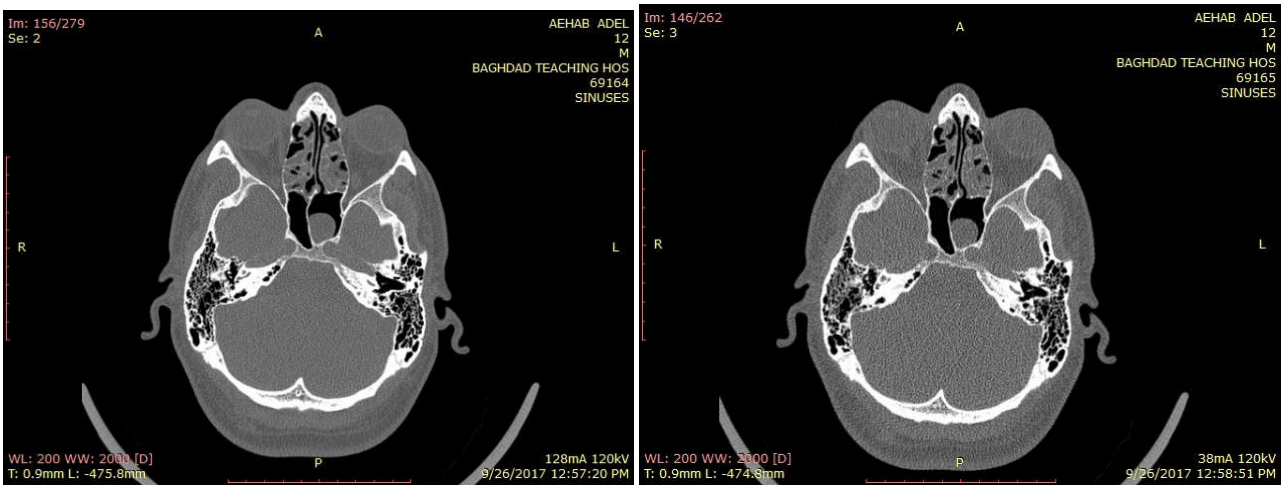

Fig.1. Axial section of multidetector CT (MDCT) scans obtained at level of sphenoethmoidal recess in 35- year-old man who presented with headache suspected to be caused by chronic sinusitis. A, Reformation of standard -dose MDCT scan shows abnormal right and normal left sphenoethmoidal recess. No discrepancies among reviewers or between pairs of reviewers were noted. B, low -dose MDCT scan shows abnormal right and normal left sphenoethmoidal recess. As with A, no discrepancies among reviewers or between pairs of reviewers were noted

Fig. 2. Coronal multiplanar reformations of multidetector CT (MDCT) scans obtained at level of chronic sinusitis. A, Reformation of standard-dose MDCT scan shows abnormal right OM complex, mild left maxillary mucosal thickening. No discrepancies were noted. B, Reformation of low-dose MDCT scan shows abnormal right OM complex, mild left maxillary mucosal thickening. As seen in A. No discrepancies were noted

DISCUSSION

CT scanning of paranasal sinuses is a crucial imaging modality in the evaluation of patient complaining from sinonasal disorders, So, many studies were done in a trial to reduce radiation dose as low as possible. Our study results revealed that the diagnostic & associated radiological features of acute or chronic sinusitis can be clearly & adequately visualized on the low-dose protocol scans with no significant difference to the standard-dose protocol although, there was some increase in noise which had no significant impact on image quality.

On individual bases, there were no major differences in the total & individual scores between the two protocols given by the 1st and 2nd reviewers & only small differences in the scores given by the 3rd reviewer. The results demonstrate that when identifying diagnostic image quality & the clinically relevant and important anatomical structures of the sinonasal cavities, the number of differences between findings in low-dose and findings in standard-dose MDCT scans either did not differ or were even less than the number of differences among all reviewers, depending on the features considered. Little discrepancies in evaluation of image quality were thought to be

caused by mild abnormality & those occur in evaluation of anatomical structures were thought to be related to reviewer human factor. The results of our study were in line with many previous studies of the same purpose such as the study done by Askoy et al which point to high-pitch, ultra-low-dose CT scanning can effectively image the paranasal sinuses (Aksoy, 2003). All anatomic structures were found to be well identified in all patients groups take part in this study, except for the ethmoid foramen (to clarify the ethmoid artery), which was not identified no matter which type of protocol was used. Normal and pathologic mucosal structures of the sinonasal cavities were also well identified. In a study performed by Tack D et al, fifty patients were examined by 10 and 150 effective mAs concludes that discrepancies of noted abnormalities much less affected by dose reduction than affection by human element of radiologist reviewer observation (Tack, 2003). A study performed by Duvoisin et al yields that tube current as low as 30 mAs is adequate for analysis of normal and abnormal anatomical structures (Duvoisin, 1991). Kerney et al concluded that the overall quality of the scans & clarity of relevant anatomical structures were not affected by scanning at tube current 40 mAs (Kearney, 1997). In a study performed by Lam et al, 30 patients were examined by MDCT with tube current 40 mAs & 100 mAs found that the reduction of mAs from 100 to 40 resulted in a significant reduction of radiation doses to the lens and thyroid gland by 55.4% and 38.8% respectively without any significant effect to the diagnostic image quality and evaluation of the clinically relevant anatomical structures (Lam, 2009). Sohaib et al also found that clinically relevant anatomical structures can be adequately seen on scan done at current 50 mAs (Sohaib, 2001).

Conclusion

Standard-dose MDCT should not be considered the only supreme method of imaging of sinonasal cavities and reduction of radiation dose should be applied wherever is possible by reduction of tube current (mAs) in CT scanning of paranasal sinuses.

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