The Effect of mAs and Slices Number on Image Quality in Pediatrics CT Scan

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ABSTRACT

The goal of clinical computed Tomography(CT) is to produce images of diagnostic quality using the lowest possible radiation exposure, Degradation of image quality, with increased image noise and reduced spatial resolution is a major limitation for radiation dose reduction in (CT). This can be counteracted with new post-processing image filters and iterative reconstruction (IR) algorithms that improve image quality and allow for reduced radiation doses. Implementation of new methods in clinical routine requires prior validation in phantoms and clinical feasibility studies including comprehensive evaluation of diagnostic image quality. The main objectives of this dissertation were to compromise between radiation dose and image quality in brain (CT) scan at different (mAs) and different slice number by using (MATLAB) software for evaluation of image quality.

One hundred cases at Alkhalel Hospital were study at radiology department. Brain CT cases were selected from Siemens Computer tomography (64 slices) which is running at different kvp range (80, 110, 130) and 50 mAs. Dose measurement for brain CT scan where determined by using CT-Expo software. The results show that the image quality where proportional to the mAs and dose. qualitative and quantitative image quality were in good agreement.

Keywords: This work was carried out in Alkhalel Trauma Hospital

Introduction :

The first commercially viable CT scanner was invented by Sir Godfrey Hounsfield in Hayes, United Kingdom, at EMI Central Research Laboratories using X-rays. Hounsfield conceived his idea in 1967. [1] The first EMI-Scanner was installed in Atkinson Morley Hospital in Wimbledon, England, and the first patient brain-scan was done on 1 October 1971. [2] It was publicly announced in 1972. The original 1971 prototype took 160 parallel readings through 180 angles, each 1° apart, with each scan taking a little over 5 minutes. The images from these scans took 2.5 hours to be processed by algebraic reconstruction techniques on a large computer. The scanner had a single photomultiplier detector, and operated on the Translate/Rotate principle .In the U.S., the first installation was at the Mayo Clinic.

As a tribute to the impact of this system on medical imaging the Mayo Clinic has an EMI scanner on display in the Radiology Department. Allan McLeod Cormack of Tufts University in Massachusetts independently invented a similar process, and both Hounsfield and Cormack shared the 1979 Nobel Prize in Medicine. [3, 4]

The Introduction of CT into clinical practice in1972 has been followed by a dramatic increase in the number of CT examinations performed, More than 27 million CT examinations were performed [5, 6] in the United States in 1997, an increase of 10% per year. [7] With the advent of improved CT technology such as multi slice detectors, the use of CT in diagnostic radiology will continue to increase for the foreseeable future. Radiation doses delivered to patients undergoing CT examinations are relatively high in comparison with doses associated with other types of diagnostic radiologic procedures. In 1989, CT represented only 4% of the radiologic Examinations performed in the United Kingdom, yet accounted for more than 40% of the collective medical radiation dose to the population. [8] Radiation doses in CT are well below the threshold doses for the induction of deterministic effects such as erythematic and depilation and it estimates that there is a small but quant risk of stochastic effects, such as cancer [9].

The reported average radiation dose for abdominal/pelvic CT is 15 mSv. At Mass General Imaging the dose is about 5.4 mSv for initial diagnosis [10] Patient doses may be lower if high-resolution CT is performed using thin sections, the patient dose is directly proportional to the value for mille Ampere, Dose and image quality in CT generally depend on the choice of technique factors that are used to perform a pelvic CT examination including the peak kilo voltage, mill Ampere- seconds, section thickness, and number of sections. , [11]This procedure permits the computation of the mean patient dose and total energy imparted for a given pelvic CT examination. At a fixed radiographic tube potential, the patient effective dose is directly proportional to the selected tube current, the section thickness, and the total number of sections obtained, will receive an effective dose of about 6.0 mSv, The predominant risk to patients undergoing pelvic CT is Interaction of outer (Allergic Reaction): reaction resulting from exposure to the substance disparate, especially iodine. It may be a slight interaction and leads to rash or severe and poses a threat to a person's life. Exposure to radiation may increase the risk of cancer in the future. This possibility remains a bit, and is linked to the number of computerized tomography tests that are made. Although some uncertainty exists about the radiation risks at the exposure levels normally encountered in diagnostic radiology the best estimate currently in use for the general population is a 5% risk per Sievert for cancer mortality, [12]An effective dose of 5.4 mSv for brain CT scan thus corresponds to a nominal cancer fatality risk of approximately 3 per 10,000 patients reduce the typical adult effective dose from 5.4 to 6mSv. This decrease corresponds to a 57% reduction in patient dose with no adverse impact on image quality.

In this study patients underwent CT of the brain with a 16-philipes scanner with automatic exposure control in the x, y, and z planes (noise index, 11.5; tube rotation speed, 1 second; maximal x-ray tube capacity, 800 mA; slice thickness, 5 mm; slice interval, 5 mm; table speed, 40 mm/rotation; pitch, 1, tube voltage, 120 kVp,50mAs.

Experimental Protocol :

CT scans were all obtained at different kVp range (80, 110, 130) on a CT- scanner (Siemens -64). Initial scanning was performed using 286 mAs and a scan time of 1 sec, corresponding to a radiographic technique of 248 mAs. Scans were obtained using 5-mm collimation and a pitch of 1.5:1 to generate a set of four to five helical images using a 5-mm reconstruction interval and a “detail” reconstruction algorithm.

The first such set was obtained at 248 mAs, which is the standard for brain CT examinations at ALKHALEL Hospital. Subsequent sets were obtained at decreasing levels of 160, 141 mAs in order to decrease the cumulative radiation dose in a repeatedly imaged region. Each set of images was assessed immediately after reconstruction by the radiologist .

These images were printed to a laser camera using a 3 × 4 format, in pairs consisting of brain . Figure 1.1 shows image obtained at 145mAs.

Figure.1.1.Representative image of brain at 145mAs.

Evaluation of Image Quality Versus mAs:

Twelve patient images were randomly selected from 200 pediatric cases. For each patient examination, four images lacking any annotation were generated on sheets of 14 × 17 film. Each film was placed in random order in an envelope, resulting in 16 envelopes containing two pairs of images. Three interpreters, all board-certified radiologists who routinely review brain CT images, were used in this study. Each observer was asked to order the two pairs of images in each envelope according to image quality, from best to worst, which was completed in a single sitting.

For each observer, the average rank was computed for 16 images generated at each technique factor. In this manner, average ranks for each observer were obtained at each technique factor. Observers were also asked to explicitly identify any images that were deemed to be of less than diagnostic quality. The expected rank of CT images obtained at 300 mAs would be 4, whereas the rank of images obtained at 280mAs would be 3.

Mat lab Software :

Mat lab is a data analysis and visualization tool which has been designed with powerful support for matrices and matrix operations. And its own powerful programming language. One of the reason that Mat lab has become such an important tool is through the use of sets of Mat Lab programs designed to support a particular task. These sets of programs are called tool boxes, and the particular tool box of interest to us is the image processing toolbox which have been used to assess the image quality in this work, the toolbox used for this purposes is standard deviation (sd1). All the images has been entered as input data and standard deviation for each image has been calculated. Images with high sd1will have best image contrast.

Table 1-1 Patient input data for Siemens-64 at ALKHALEL Hospital and total effective dose for pediatrics brain scan .

s.n of pt	sex	age	Slices thickens	No of slices	mAs	KV	Dose mSv	contrast	Sd	Observer Score(30)	contrast to noise ratio
73447	M	16Y	5mm	30	170	130	41.23	NO	71.9006	26	45.354
72496	M	9Y	1mm	128	145	130	35.54	NO	70.9647	25	42.626
72393	M	1Y	5mm	41	219	110	37.04	NO	71.2355	25	45.945
72495	M	8Y	0.6mm	199	286	110	35.52	NO	81.5678	28	48.423
72519	M	10Y	5mm	30	242	110	40.88	NO	76.4742	27	42.934
73517	F	6Y	2mm	95	141	110	11.00	NO	70.9825	25	40.342
26299	F	2Y	5mm	33	199	110	33.67	NO	76.4489	27	46.654
72405	M	2m	5mm	21	169	110	28.62	NO	70.1963	25	42.783
72623	M	13Y	5mm	31	160	130	39.20	NO	73.0751	26	42.532

72843	F	1Y	5mm	26	232	110	39.18	NO	72.8313	26	44.632
72716	M	12Y	5mm	46	148	130	36.24	NO	73.6047	26	42.623
72988	F	1Y	5mm	28	183	110	30.63	NO	81.7264	28	45.792

Results and Discussion:

It's clear from Fig 1.2. A which illustrate different brain images at constant Kvp (110) and different mAs . image No. 2 and 3 show high score , 27 and 27 respectively . which is confirmed by contrast to signal ratio (46.65 and 42.954) . and further confirmation was done as shown in Fig 1.3 which dictates high effective dose (1.527 and 1.612) as shown log scale .

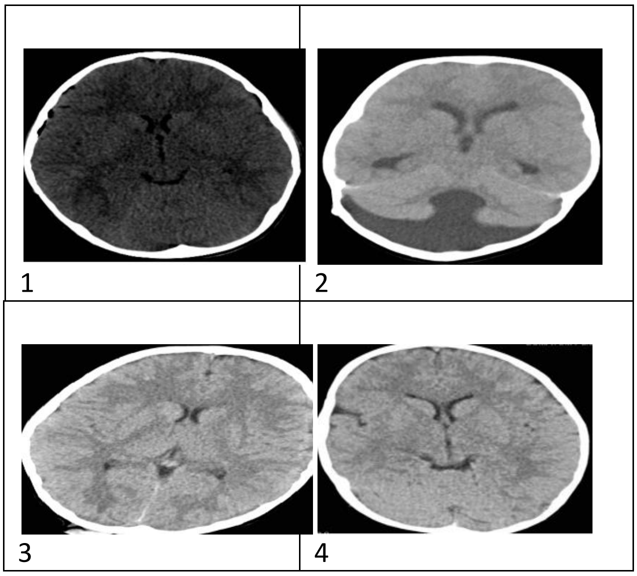

Fig 1.1A Different Brain images at different mAs and constant kvp (110)

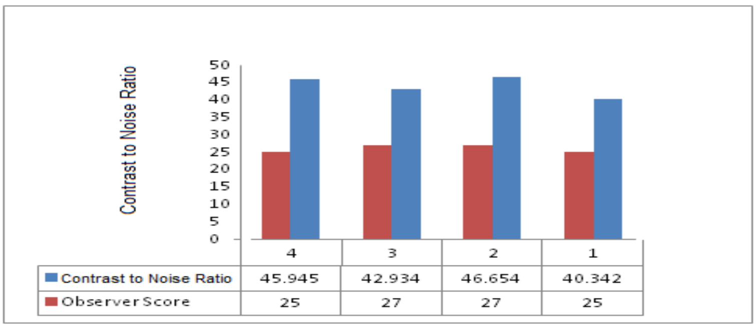

Fig 1.2 Correlation between contrast to noise ratio and observer scores for different brain images.

The Fig (1.3) shown law effective dose at slices although the relation between slices thickens and dose as inverse proportional . but at this slice thickens the operation mAs of the CT was smaller compared to the slices thickens (5) which at cooperated at mAs (199).

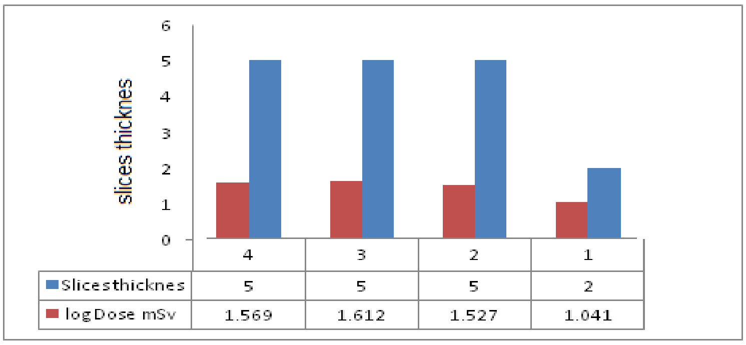

Fig 1.3 Correlation between slice thickness and Log dose (mSv) for different brain images.

Concern to the images at Fig (1.4B) Its reflects the same trend as the previous images in Fig (1.1A) .

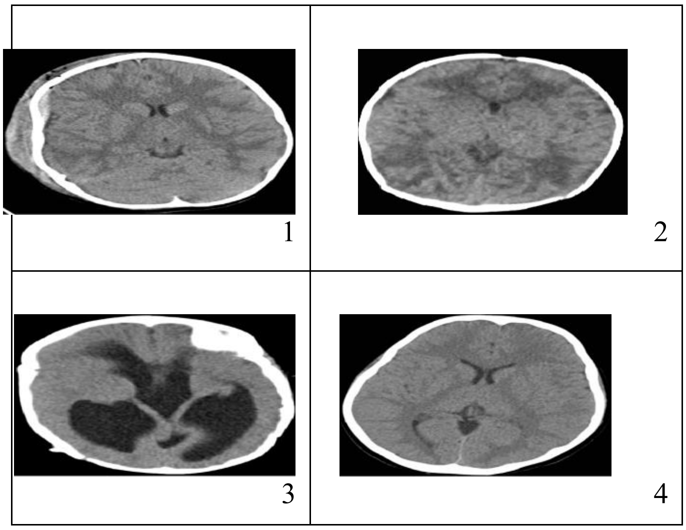

Fig 1.4B Different Brain images at different mAs and constant kvp (110)

Fig 5.4B indicates that image No.3 which slice thickens (5mm) gives high effective dose in log scale which equivalent 1.593 mSv while image No. 4 indicates low effective dose in log scale which equivalent to 1.486 these value corresponding to contrast to noise ratio (44.63 ,45.79) respectively .as shown in Fig 5.6 although image No.1 in Fig (5.4B) illustrate high contrast to noise ratio (48.42) and high observer score (28) and lees effective dose in log scale (1.55mSv) which is in good agreement regarding to the relation between slice thickens ,dose ratio and contrast .

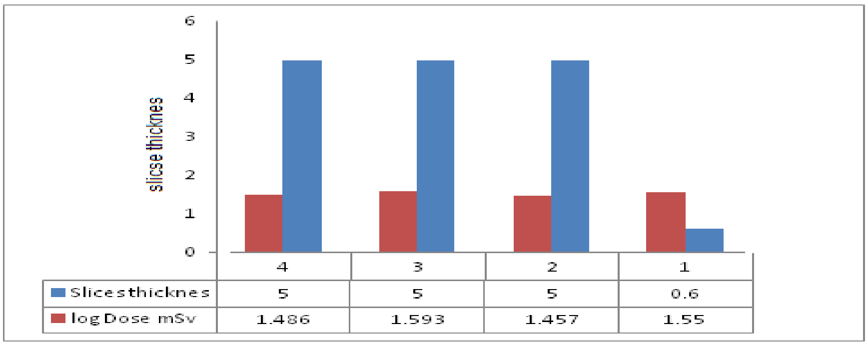

Fig 1.5 Correlation between slice thickness and Log dose (mSv) for different brain images.

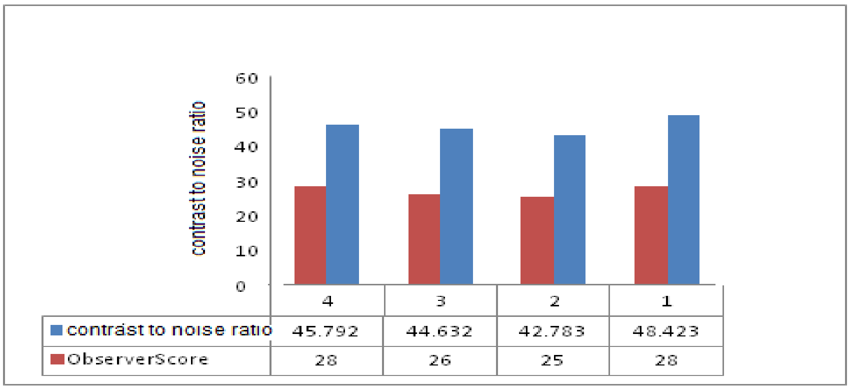

Fig 1.6 Correlation between contrast to noise ratio and observer scores for different brain images.

Regarding to image group shown in Fig (5.7C) which were taken at different mAs and constant Kvp (130) image No.1 represent low effective dose in log scale (1.55 mSv) which corresponding to mAs 145 . The contrast to noise ratio for this slice has ratio 42.626 and observer score 25 while image No .3 has higher effective dose in law scale (1.593) and contrast to noise ratio 26 which confirmed by subjective method (i .e) standard deviation (Sd) (73.07). These correlations were shown in Fig (1.8) and Fig (1.9), respectively.

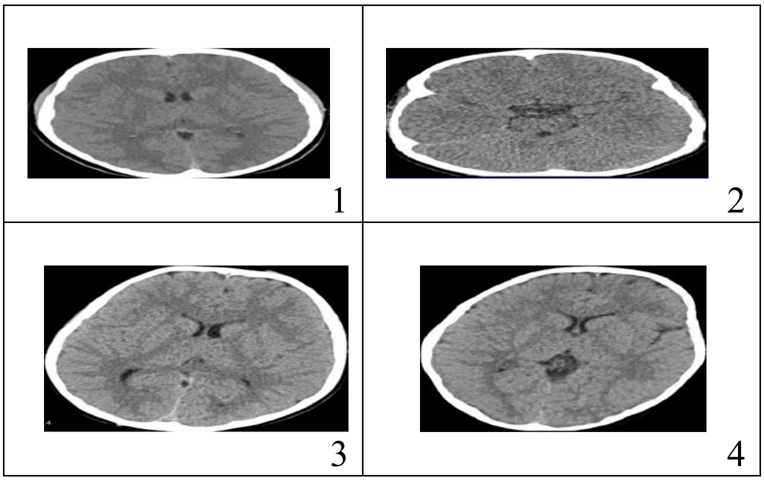

Fig 1.7C Different Brain images at different mAs and constant kvp (130)

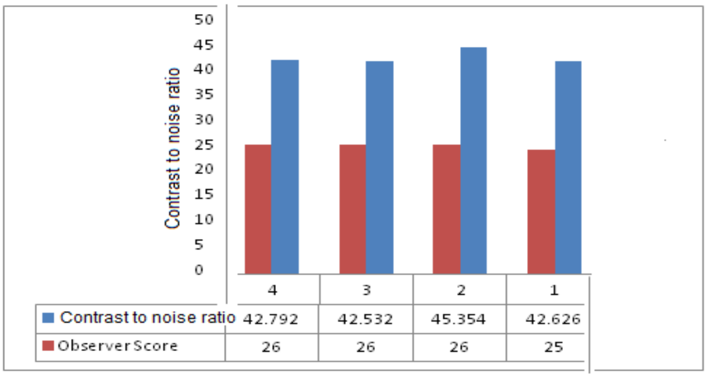

Fig 1.8 Correlation between contrast to noise ratio and observer scores for different brain images.

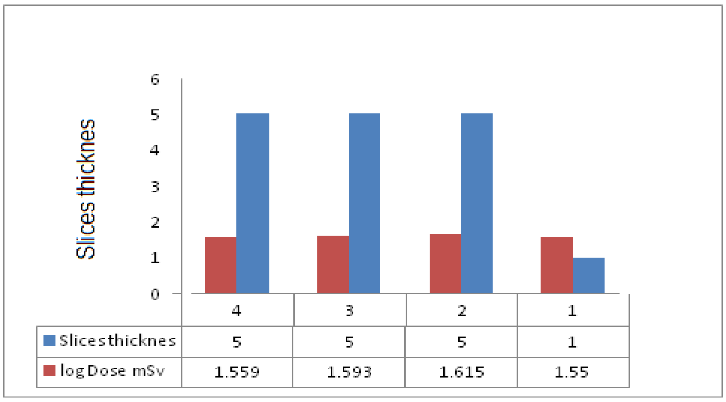

Fig 1.9 Correlation between slice thickness and Log dose (mSv) for different brain images.

Fig (1.10) illustrate the three flag parameters for image quality of brain image of group 5.7C which performed at constant Kvp (130) and different exposure mAs ranged from 145- 170 and slice thickness 5mm , except image No.1 which performed at CT protocol 1mm.

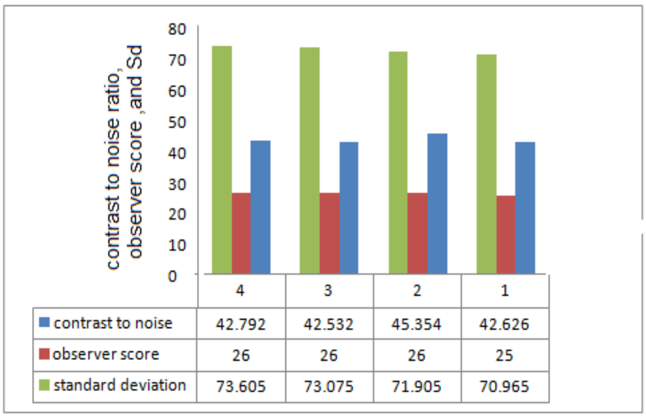

Fig 1.10 correlation between contrast to noise ratio , observer score and standard deviation for different brain images.The correlation between these flag parameters (constant to noise, observer score and Sd) where in good agreement . i.e as contrast incre4ased the standard deviation will increase as well as confirmed by the three radiologists.

Conclusion :

From the different brain images performed at different exposure current (mAs) and operating CT voltage (kvp) and deferent slice thickens protocols . we might conclude the following :

- ❖ As operation mAs increase at constant voltage (kvp) the exposure dose will increase as well as the contrast .
- ❖ As mAs increase and slice thickens decrease the dose will increase as well as the contrast will be improved .
- ❖ Regarding to the new CT generation (64 slice) the number of slices will Effect the image quality and the dose per slice, i.e as the number of slice increase per shot the dose ratio will decrease compared to the forth CT generation which has fixed slice thickens and collimator .
- ❖ Introducing the subjective evaluation for image quality will improve the image assessment for radiologists.

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