Correct patient centering increases image quality without concomitant increase of radiation dose during adult intracranial computed tomography

Al Mohiy H[1*]; Emad Alasar 2* and Charbel Saade [3*]

[1]-[2]Department of Radiological Science, King Khalid University, Abha, Saudi Arabia.

[3*]Department of Diagnostic Radiology, American University of Beirut Medical Center, Lebanon

Abstract

Purpose: To evaluate the impact of patient centering and radiation dose during intracranial computed tomography (ICT) on quantitative and qualitative image quality.

Materials and Methods: 500 consecutive patients who underwent ICT were retrospectively reviewed using a 128-slice CT scanner (Definition AS+, Siemens, Germany). Patients were subjected in equal numbers to one of two positioning protocols: Group A, poorly centered; and Group B, involved accurate centering prior to imaging. Gray-white matter (GWM) conspicuity, contrast-to-noise (CNR), and signal-to-noise (SNR) in each group were calculated. Qualitative image quality in terms of GWM differentiation, distinctness of posterior fossa contents, and overall diagnostic acceptability were evaluated by two neuroradiologists. The dose length product (DLP), CNR, SNR, and noise were measured between each group and data generated were compared using Mann-Whitney U non-parametric statistics. Visual grading characteristic (VGC) and kappa analyses were performed.

Results: The mean noise index was significantly lower in group B (2.61 ± 0.29) compared to A (2.66 ± 0.21) ($p<0.02$). The mean attenuation of GWM, SNR, and CNR in the frontal lobe (A;1:0.77, 0.84, 8.70 ± 1.36 and B;1:0.65,0.85, 15.32±1.21) ($p<0.02$), occipital lobe (A;1:1.10, 1.18, 10.79±2.11, and B;1:0.94,0.64,14.41±3.09) ($p <0.04$), and cerebellum (A; 1:0.79, 0.90, 12.56±4.08 and B; 1:0.82,0.87,14.07±2.28) ($p<0.04$) were significantly higher in group B compared to A, while the globus pallidus, caudate nucleus, and optic track in the basal ganglia demonstrated no difference in each group ($p>0.05$). Mean DLP demonstrated no significance between each group (A: 1312.03 ± 133.92, B: 1298.11 ± 130.61). The qualitative analyses demonstrated significant increases in VGC for each reader ($p<0.02$) and inter-observer agreement was significantly increased in protocol B (k=0.81) compared to A (k=0.62).

Conclusion: Correct patient centering increases the CNR and SNR in both GWM in the left and right hemispheres of the brain during ICT.

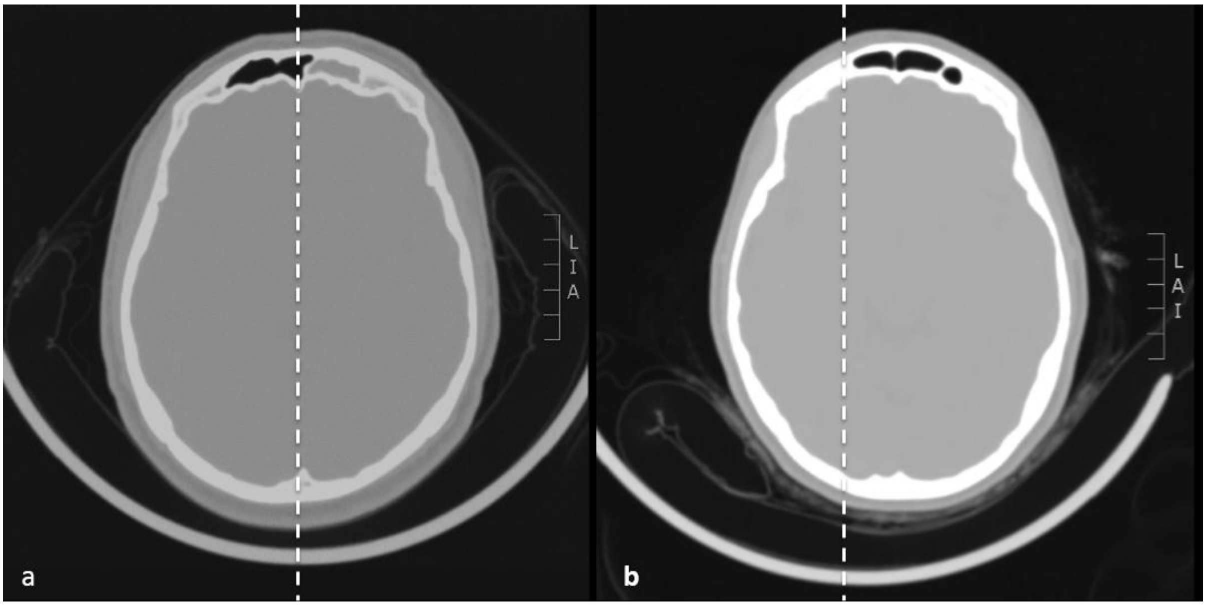

Figure 1. Optimal head centering (a) and sub-optimal head centering (b) during intracranial CT.

Quantitative image analysis

A neuroradiologist certified by the American Board of Radiology and with seven years' experience assessed the images. For all axial reconstructions, 4 mm circular and two regions of interest (ROI) are placed in corresponding white matter (WM) and gray matter (GM) locations (at the level of the basal ganglia) as well as in the pons (these are common areas of stroke prevalence). Signal was defined as CT density in Hounsfield Units (HU), and image noise as standard deviation (SD) of attenuation within a ROI. SNR and CNR were calculated using the following standard equations [20]:

$$SNR = \frac{mean\ HU\ of\ tissue\ in\ ROI}{SD\ of\ HU\ in\ ROI}$$

$$CNR = \frac{mean\ GM\ HU - mean\ WM\ HU}{\sqrt{[(SD\ GM\ HU)^2\ + (SD\ WM\ HU)^2]}}$$

Results

For each protocol, the mean anterioposterior, lateral skull diameters, and cranium circumference demonstrated no significant difference (Table 3).

Table 3: Anatomical correlation between skull parameters and cranial circumference and diameters.

	Group A	Group B	p value
Skull Parameters			
(mm)	174 ± 5.8	173 ± 4.9	> 0.05
Anterioposterior			
Diameter (mm)	136 ± 2.8	138 ± 1.9	> 0.05
Lateral Diameter	491 ± 11	493 ± 9	> 0.05
Head			
Circumference	147 ± 21	146 ± 19	> 0.05
Scan Range (mm)			

Note – Data are mean ± standard deviation

Noise measurements

The mean noise was significantly greater in Group A (2.66 ± 0.21) compared to Group B (2.61 ± 0.29) ($p < 0.02$). The mean noise index increased in Group A compared to B when the patient was in the center of the field of view (Table 4).

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