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Correlation between the Exposure Parameters and Dose Values of Different CT Examinations

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Abstract: *The aim of this study was to correlate between the CT exposure parameters and dose values. This study was carried out in five major hospitals radiology department and diagnostic centers in Khartoum as a retrospective study, conducted from 100 patients who referred for common CT exams. The methodology was based on a retrospective collective data, imply a total of 100 common CT exams for pediatric and adults patients. The results have been highlighted in forms of bars, and correlations and the analysis revealed that: the frequency of patient referred to CT examination was higher among male group and represents 66% of the sample relative to female that represents 34% and the common cases referred for CT examination were the sinuses, abdomen, renal, chest and the neck that represents the following frequencies 21%, 20%, 17%, 14% and 6% respectively. The correlation analysis revealed that: both the CTDIvol and DLP in (mGy) increases slightly following the aging of patients in a linear form that could be represented in the following equations form: y = 7.915x + 581.3 and y = 0.293x + 15.75 for DLP and CTDI respectively. And the correlations between milli-ampare (mA) versus CTDIvol and DLP in (mGy) showed that: there is insignificant linear relationship between the mA and CTDIvol and DLP in (mGy) as R2 = 0.1 & 0.09 respectively while the correlations between the number of images versus CTDIvol and DLP in (mGy) revealed that both the CTDIvol and DLP decreased following the number of image done. Also the correlations between exposure time versus CTDIvol and DLP in (mGy). It shows that, there is inversely linear relationship between exposure time in (ms) versus DLP and CTDIvol.*

Key words: *CTDI, DLP, Exposure Parameters.*

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I. Introduction

Radiation dosereduction is very important in radiologic studies, particularly with regard to multi-detector CT. and the growth in the volume of multi-detector CT exams and studies performed worldwide, the increasing use of CT in susceptible populations (including children), and growing concerns on the part of the general public with regard to radiation exposure have provided an impetus for performing these studies with the minimum possible radiation dose. (1). It is important to understand all the factors and parameters thatcan affect radiation dose and image quality and examine how these can be altered to reduce dose. In this review paper, we discuss the manipulation ofeight CT parameters that can be changed by the technologist, while designing or altering scan protocols, to reduce patient radiation dose and these parameters includedetector configuration, tube current, tube potential (kVp), reconstruction algorithm, patient positioning, scan range, reconstructed slice thickness, and pitch(2). Increases in tube current or the product of tube current and scan time (mAs) result in improved image quality, decreased image noise, and increased patient dose. In general, the relationship between tube current and patient dose is essentially linear, with increases in mAs resulting in a comparable percentage increase in patient dose (3).As the reconstructed slice thickness decreases, the number of photons within each voxel also decreases, resulting in increased image noiseto maintain constant noise levels within an image with a smaller slice thickness, the radiation dose must be consequently increased Saini S. (3)the larger the reconstructed slice thickness used, the lower the patient dose. It is worth repeating, however, that the reconstructed slice thickness cannot be smaller than the acquired slice thickness.Detector configuration is a term encompassing the number of data channels being used in the z axis and the “effective detector thickness” of each data channel, both the number of channels used and the effective detector thickness can be varied depending on how many channels in a detector array are used, which channels in a detector array are used, and the manner in which different channels are combined (3).The detector configuration should be determined on the basis of the type of study performed, the necessary slice thickness for multiplanar reformations (MPRs), and the need for 3-D images. Different scanners from different manufacturers have different included detector channels, and the detector configurations available on different equipment can vary widely [(4)].Reducing kVp can be an effective means of reducing the radiation dose imparted during an examination. As a general rule of thumb, the radiation dose changes with the square of kVp, and a reduction in kVp from 120 to 100 reduces radiation dose by 33%, while a further reduction to 80 kVp can reduce dose by 65% [(5,6)]. Improper patient positioning can have a significant impact on both image noise and patient surface dose. [(7)]Improperposition leads to the need to repeat the exam and this lead to unnecessary patient dose.For many CT applications, significant reductions in scan range may be neither possible nor desirable. The scan range should be reduced to the needed minimum for any examination, although cardiac studies are certainly the most obvious applications in which a limited scan length can be used, a small scan range may be possible in many traditional body imaging applications as well: Patel et al [(8)]found that using a small scan range (from the top of the aortic arch to the bottom of the heart) in CT pulmonary angiographic studies can allow diagnosis of pulmonary embolism without any loss of sensitivity but with a reduction in radiation dose of 48%.[(8)]Pitch in the multi-detector, spiral CT era is defined as table travel per rotation divided by beam collimation. Pitch <1 suggests overlap between adjacent acquisitions, pitch >1 implies gaps between adjacent acquisitions, and pitch of 1 suggests that acquisitions are contiguous, with neither overlap nor gaps [(9)]. A smaller pitch, with increased overlap of anatomy and increased sampling at each location, results in an increased radiation dose[(9)].A number of studies using each of the different vendors' software packages have concluded that iterative reconstruction is a viable option in terms of both reducing radiation dose and improving image quality [(10-13)]. For example, a study by Kaza et al [(14)] found that iterative reconstruction techniques could lower radiation dose by up to 30% in CT enterographic studies, while still maintaining acceptable image quality.

II. Materials and Methodology

Three types of radiographic system were used during this study:GE, Optima™ CT-660, with kVp range up to 140 kVp, and mA up to 600 mA, with scanning modes: helical, axial, cine and scout, manufactured by GE Healthcare in 2010.X-Ray Tube specifications:-Performix™ 40 X-ray Tube Unit, Design optimized for exams requiring a-large number of scans without tube cooling. Maximum Power: 72kW, Dual Focal Spots, Small Focal Spot,0.9* 0.7 IEC 60336: 2005, 0.7* 0.6 IEC 60336: 1993, Large Focal Spot: This study was carried out in five major hospitals radiology department and diagnostic centers in Khartoum. This study was carried out in time between year 2013 to 2016.The study has been carried out as retrospective study. The medical records for CT dose and digital x-ray doses for 300 patients were reviewed, and the patient aged from child to 90 years. And all information and data about patients are safely kept. The data were collected from three types of x-ray diagnostic methods , computed radiography, routine radiography and digital radiography , relative to the following variables: gender, pathologic cases, age/BMI correlated to CTDI and DLP, mA correlated with CTDIvol and DLP in (mGy), number of images correlated with CTDIvol and DLP in (mGy), exposure time correlated with CTDIvol and DLP in (mGy), also highlights the results related to conventional and digital radiography , and then analyzed by using EXCELL software in forms of bars, and correlations.

III. Results And Discussion

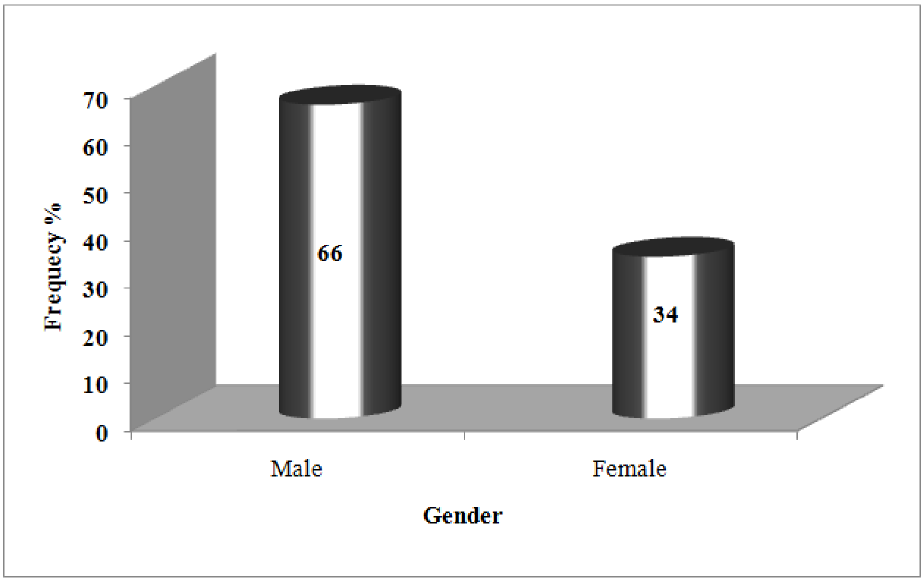

Figure.1 shows the frequency % of patients presented for CT investigations.

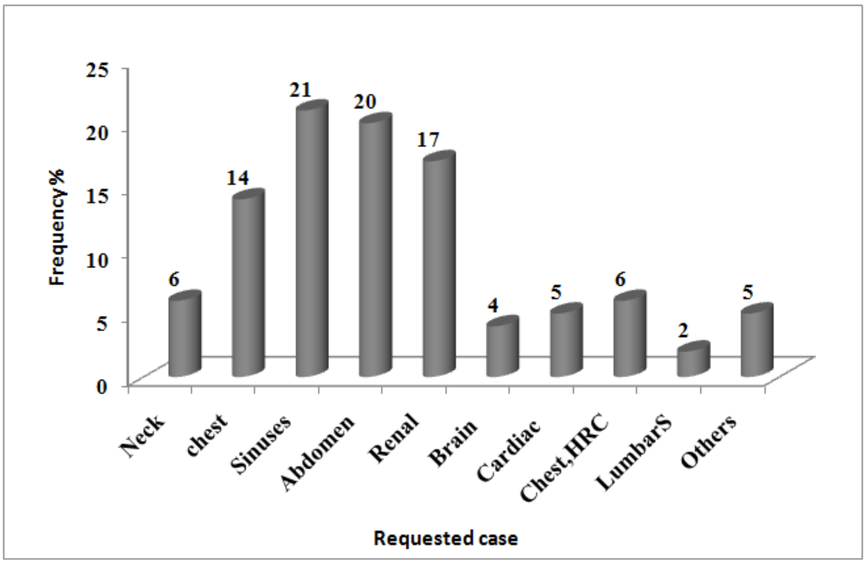

Figure.2 shows the frequency% of Requested cases for CT scanning.

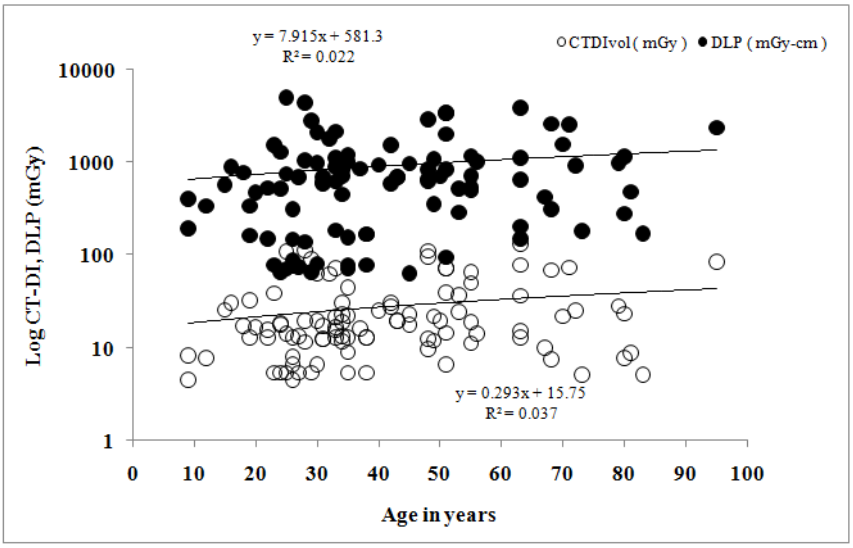

Figure.3 shows the correlations between the patients ages and CTDIvol and DLP in (mGy).

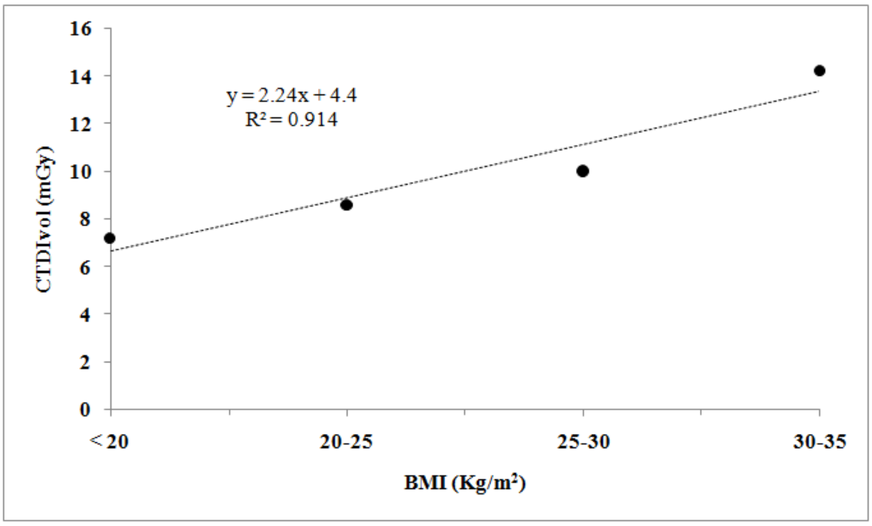

Figure.4shows the correlation between the BMI in Kg/m^2 and the $CTDI_{vol}$.

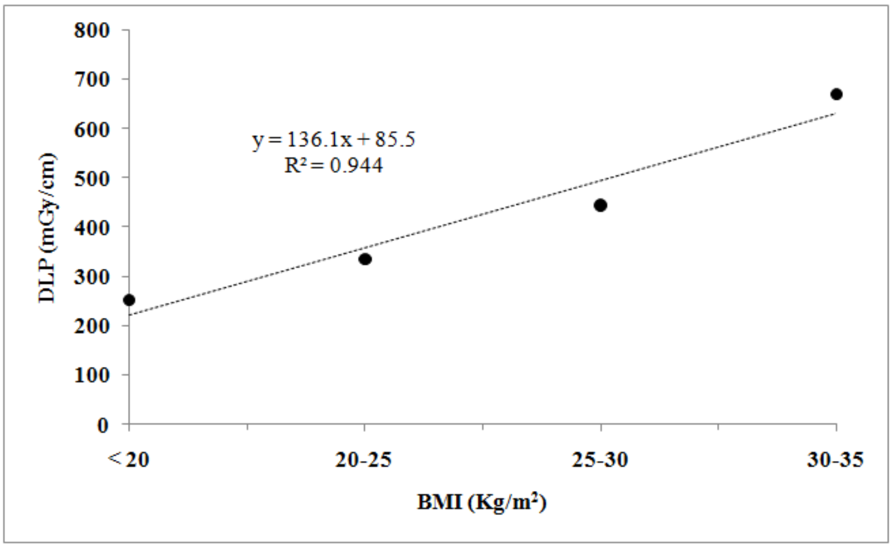

Figure.5 shows the correlation between the BMI in Kg/m^2 and the DLP in mGy/cm

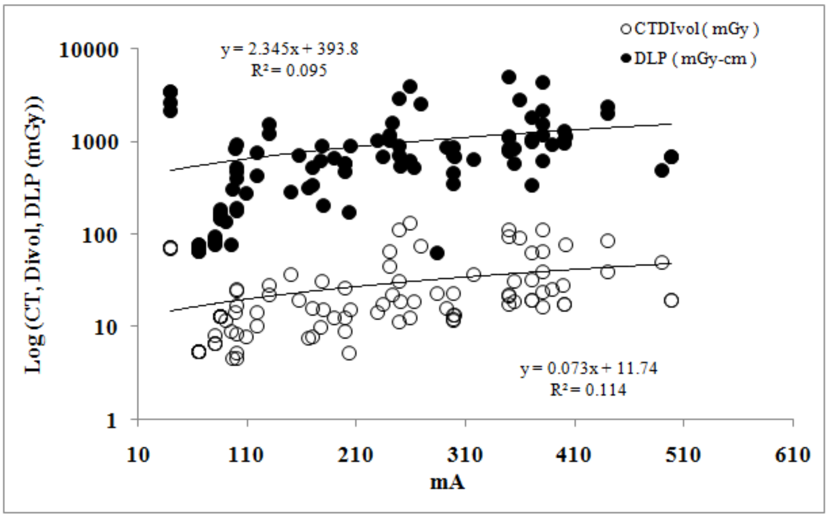

Figure.6 shows the correlations between mA and $CTDI_{vol}$ and DLP in (mGy).

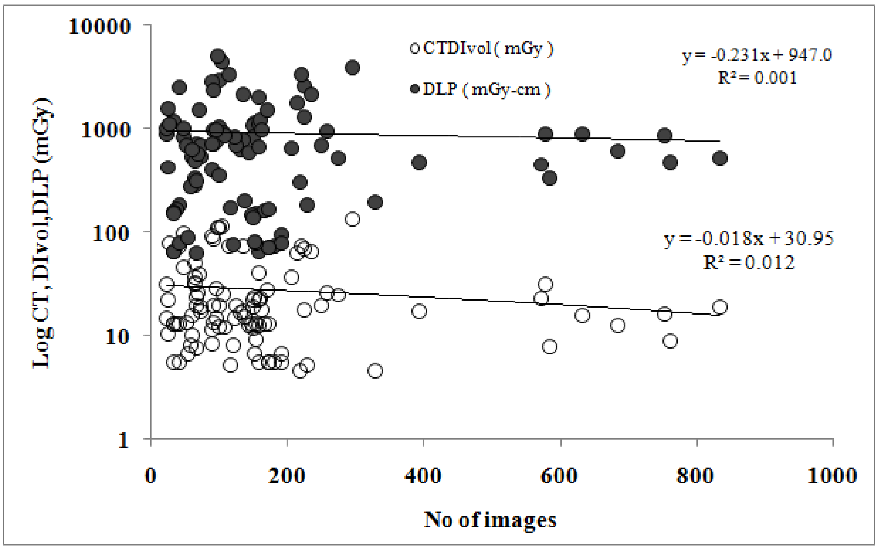

Figure.7 shows the correlations between No of images and $CTDI_{vol}$and DLP in (mGy/cm).

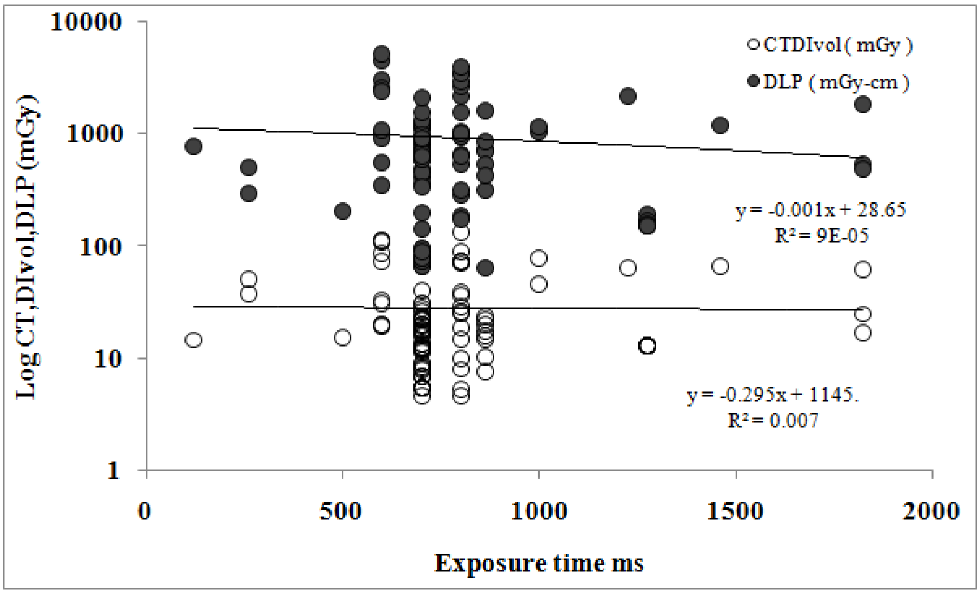

Figure.8 shows the correlations between exposure time and $CTDI_{vol}$ and DLP in (mGy).

IV. Discussion

(Figure.1) shows the frequency % of patients presented for CT investigations. The study revealed that the frequency of patient referred to CT examination was higher among male group and represents 66% of the sample relative to female that represents 34%, such high incidence of male patients referred to CT examination is ascribed to the common factors of injuries to which the male encountered as has been mention by Oikonomou and Prassopoulos, [(15)],that: male are more susceptible to chest traumatic factors than female e.g. in football, car accidents, violent entertainments and acrobatic games.(Figure.2) shows the frequency% of pathological cases presented for CT scanning. The data shows that: the common cases referred for CT examination were the sinuses, abdomen, renal, chest and the neck that represents the following frequencies 21%, 20%, 17%, 14% and 6% respectively. Such high incidence among these cases could be ascribed to the common encountered with traffic accidents and the shortage of conventional x-ray to reveal and detects some related cases such as liver hematoma, pulmonary contusion, emphysema and sternum fracture due to exposure factors variation for the organ to be visualized.(Figure.3) shows the correlations between the patients' ages and $CTDI_{vol}$and DLP in (mGy). For the importance of CTDI (The dose from the primary beam plus scatter from surrounding slices and DLP (is the product of the length of the irradiated scan volume and the average CTDIvol over that distancein view of image quality, systems comparison, determine the amount of radiation used to perform the study and for protocols comparison. Hence the study reveals that both the $CTDI_{vol}$and DLP in (mGy) increases slightly following the aging of patients in a linear form that could be represented in the following equations form: y = 7.915x + 581.3 and y = 0.293x + 15.75 for DLP and CTDI respectively, with important notation that: the correlation was not so significant as R^2 = 0.02 and 0.03 respectively and the DLP was high than the CTDI for the same patient among all sample. (Figure. 4) shows the correlation between the BMI in Kg/m^2 and the $CTDI_{vol}$. The study shows that there is linear proportional relationship between the two parameters that could be fitted in the following equation: y = 2.24x + 4.4, where x refers to BMI in Kg/m^2 and y refers to $CTDI_{vol}$ which is so significant as R^2 = 0.9. And such increasing in the $CTDI_{vol}$ ascribed to the factors dependent such as the scattered radiation and the system output. Same result has been obtained by Boos et al, [(16)], in which they deduced that: the $CTDI_{vol}$ for the obese (30-35 Kg) and extremely obese (>35 Kg) has exceeded the National Diagnostic Reference levels.In (Figure.5) that shows the correlation between the BMI in Kg/m^2 and the DLP in mGy/cm, also there is linear proportional relationship between the two parameters that could be fitted in the following equation: y = 136.1x + 85.5 where x refers to BMI in Kg/m^2 and y refers to DLP. The high dose increasing following the BMI increment which also shown in the study carried out by Boos et al, [(16)] is due to principle that: DLP is a dependent factor of the dose per volume cross section of CT slice along the length of entire imaged organ, which is also deduce that the DLP is higher than the $CTDI_{vol}$.(Figure.6) shows the correlations between mA and $CTDI_{vol}$ and DLP in (mGy). It shows that: there is insignificant linear relationship between the mA and $CTDI_{vol}$ and DLP in (mGy) as R^2 = 0.1 & 0.09 which is agreed with the fact that mentioned by Dong F et al, [(17)] in conventional radiology and stated that: there is a linear relationship between the tube current-time product and the dose.(Figure.7) shows the correlations between the number of images and $CTDI_{vol}$and DLP in (mGy). It reveals that both the $CTDI_{vol}$and DLP decreased following the number of image done, however such relationship is insignificant as R^2 = 0.00 and the scientific justification for that is ascribed to the fact that: the number of images could be controlled by image reconstruction program. (Figure.8) shows the correlations between exposure time and $CTDI_{vol}$ and DLP in (mGy). It shows that, there is inversely linear relationship between DLP and $CTDI_{vol}$ and the exposure time in ms, which is not significant as R^2 = 0.0, and there is notable presented in the high value of DLP relative to $CTDI_{vol}$ which is ascribed to DLP dependent factor.

V. Conclusion

After the successful achievement of the research objectives, the conclusion of the following research could be summarized and cited to layout the most important facts related to Evaluation of Patient Doses in Diagnostic Radiography as follows:The frequency of patient referred to CT examination was higher among male group and represents 66% of the sample relative to female that represents 34% and the common cases referred for CT examination were the sinuses, abdomen, renal, chest and the neck that represents the following frequencies 21%, 20%, 17%, 14% and 6% respectively. Also the $CTDI_{vol}$ and DLP in (mGy) increases slightly following the aging of patients in a linear form. There is insignificant linear relationship between the mA and $CTDI_{vol}$ and DLP in (mGy), while the correlations between the number of images versus $CTDI_{vol}$and DLP in (mGy) revealed that both the $CTDI_{vol}$and DLP decreased following the number of image done.

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