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Francis AKIANA
Department of Radiobiology of the Doctoral School of Engineering Sciences of the University of Abomey Calavi, BP2009. Cotonou, Benin

Clément Dossa GANDONOU
Cellular Environment Laboratory, Faculty of Sciences and Cytogenetics, University of Paris, France

Radhia M'KACHER
Faculty of Science and Technology, University of Abomey-Calavi, Laboratory of Enzymology and Protein Biochemistry, 01BP: 188, Cotonou, Benin

Daton MEDENOU
Department of Radiobiology of the Doctoral School of Engineering Sciences of the University of Abomey Calavi, BP2009. Cotonou, Benin

Corresponding Author:
Francis AKIANA
Department of Radiobiology of the Doctoral School of Engineering Sciences of the University of Abomey Calavi, BP2009. Cotonou, Benin

Effects of low doses of radiation on children after exposure to scanner in the Republic of Congo

Francis AKIANA, Clément Dossa GANDONOU, Radhia M'KACHER and Daton MEDENOU

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Abstract
Computed tomography is a technique used to evaluate the diagnostic reference level, like many African countries, particularly in Congo Brazzaville, where populations are used this technique. During the collection of information, 76 pediatric patients aged 0 to 14 years were identified. The aim of this study was to assess or evaluate the consequences of small amounts of radiation on children after being exposed to the scanner. According to recent epidemiological research, it has been found that children and adolescents are at higher risk of cancer following exposure to low doses of ionizing radiation from a diagnostic scanner, with a cumulative dose of approximately 50 mSv. Blood samples were taken from 61 patients. 30 healthy donors of whom were included as controls. Hematological parameters are analyzed using automated statistical analysis. A blood sample is obtained before and 24 hours after exposure to the scanner at the Pierre MOBENGO Central Army Hospital (A), Banche Gomez (B), two different hospitals in Congo-Brazzaville. After 24 hours of exposure to the scanner, there1 was a significant drop in red blood cells and hemoglobin in all patients ($p = 0.0002$ and $p = 0.0004$). There is a significant correlation between abdominal-Pleven CT and fluctuations in white blood and granulocytes.
An increase in lymphocytes was observed in young patients who were exposed to low doses of radiation. These variations were reflected inflammatory reactions. After fluorescence hybridization staining of telomeres and centromeres, [1]chromosomal and telomeric aberrations were observed. It is important to emphasize that the increase in chromosomal and telomeric aberrations is influenced by age. Chromosome instability is primarily caused by loss of telomere functionality.

Keywords: Dicentric, acentric rings, telomere, centromere, dose, young patients

Introduction
You [15] can be exposed to very small amounts of ionizing radiation. An inevitable phenomenon today, linked not only to natural exposure which represents more than 80% of sources of low dose irradiation but also to technological progression and the the introduction of ionizing radiation into medical practice. This is a problem widely debated in the literature with significant consequences in terms of radioprotection of populations exposed to ionizing radiation. The problem of low doses and the resulting effects are currently major public health problems for which the only data we have been essentially epidemiological data on the incidence of late complications such as secondary (UNSCEAR *et al.* 2006) and cardiovascular complications (Haddy *et al.* 2014) [10]. Very little research has succeeded in identifying biological effects of low doses (Dauer *et al.* 2010). The practice of cerebral, thoracabdomino-pelvic, Abdomino-Pelvieene scan examinations in Congo in two structures faré hospital is nowadays a common procedure. However, it implementation must be sufficiently taken into account the rules of radiation protection of patients, especially when it is come to the pediatric age group. The objective of our study is being to show the doses received from console, hematological parameters, cytogenetic analysis and to make a cytogenetic analysis [8] of chromosomal abnormalities present in circulating lymphocytes of pediatric patients who have received treatment abdominopelvic CT in order to study the cytogenetic effects and identify the associated risks.
A 76 pediatric sample aged between 0-14 years were chosen following a questionnaire. The RAYSAFE X 2 dosimeters were used to measure the doses delivered during the examination, in comparison with those recorded at the console. The enumeration of chromosomal aberrations was carried out after marking the telomeres and centromeres.

We were interested in the next three steps, doses received, modification of hematological parameters, cytogenetics. At the end; samples from seven patients could be used (63.63%) with 3557 cells observed. Of 1447 metaphase cells were analyzed before exposure to CT, we were counted only terminal deletions (0.27%).

Materials and Methods

Study sites

In the course of our study, several biomedical materials were used. A total of 76 pediatric patients were scanned according to the selection criteria. This study was carried out in two large military and civilian hospital structures in the Republic of Congo, namely: the Pierre MOBENGO Central Army Hospital (A), Banche Gomez (B) where the scanners were carried out to carry out the examinations at the level of the different sectors of the body according to the study.

Investigation

This descriptive and cross-sectional study are carried out on two large hospitals and are carried out in two medical imaging departments including the characteristics of the equipment, such as there is information such 7as model, serial number, year of production, year of installation and other relevant information. The table below shows (Table1).

Table 1: Characteristics of scanning services equipment.

Service of CT scan	Equipment types	Model and Séries	Year and Manufacture	Year of Installation
A	Toshiba	Activision 16 1CA0882217	2008	2008
B	Neusoft	Neuviz 16	2015	2018

The hospital centers are called centers A and B. The study is carried out between July 2021 and November 2021, and out of a total of 76 pediatric patients, aged between 0 to 14 years old, are selected and have been the subject of a CT scan in both centers. Facilities are selected based on [7]the frequency of examinations performed and the ability to directly capture doses of ionizing radiation in patients at low doses. The relevant technical parameters of the CT scan are obtained displayed and saved on the console of the CT scan machines. Four types of examinations are carried out on the skull, the thorax, the abdomen-pelvis and the thorax-abdomen-pelvis and as well as the CTDIvol and the DLP are taken into account for the study.

Methods

This is a prospective cross-sectional study. This study focused on pediatric patients undergoing a thoracoabdomino-pelvic, Thoraco-Pelvic, Cerebral scan examination. Each parent or guardian, and the child himself if he is in school, received a clear explanation of the purpose of the study as did the attending physician.

The samples are transported to the laboratory in accordance with the national and/or international rules applicable to the transport of infectious substances, as indicated in the Practical Guide on the application of the regulations relating to the transport of infectious substances published by (WHO *et al.,* 1993). Sterile 10 ml tubes contain 5ml of Leibowitz L-15 heparin blood; 20% fetal calf serum and 4% dehydrated PHA, mix them for the long duration of travel, 10 ml of blood per patient. 24 hours after the scan so that it has been a homogeneous distribution of exposed lymphocytes throughout the organism. Then, the tubes are stored at room temperature (IAEA *et al.,* 2013). CT scans of the brain, thoraco-abdominal-pelvic or abdomen were performed, with and without the use of contrast material. This was done using a CT scanner with a tube voltage of 80 to 140 kV, mAs of 70 to 120, and steps of 0.8 to 1.5 mm. The EDEREX computer dosimetry system was used to determine the effective radiation dose. 4In addition, it was established following methodical instructions.

Using information such as age, gender, start and end position of the scanner (UNSCEAR *et al.* 2013), regarding the hematological analyses, the analysis of the hemograms was carried out using 6the blood count method with EDTA-K3, then the tubes were placed in an automated machine. We suck up between 2 and 5 µL of this homogenate, then we pass them through the analyzer before digitizing them. 24 hours later, the examination was repeated to confirm changes in hematological parameters of blood cells, where hematology is employed to assess the number of blood elements through the automated system for analyzing blood collected from citizens. According to (M'kacher *et al.* 2014) [29], it is possible to detect abnormalities in the three blood lines using a machine for collecting hematological parameters such as red blood cells or erythrocytes, white blood cells or leukocytes, platelets or thrombocytes. [2]Unstable chromosomal aberrations were analyzed using two slides per sample after telomere and centromere staining. We only examined metaphases which contain 46 centromeres. Chromosomal aberrations were identified based on the presence or absence of telomere and centromere sequences. The dose-length ratio was calculated using the CT dose index, which was uniformly adjusted in the CT scanner based on the length of the CT axial scan range of a body, as shown below: CTDI (mGy) × L (cm) = DLP. Dose levels for the thorax were between 1.5 and 3 mSv; for the abdomen they were between 2.5 and 5 mSv, and for the brain they were between 2 and 3 mSv.

[2] Chromosomal and telomeric aberrations were examined in T and B lymphocytes in this study. Before and 24 hours after analysis, peripheral blood lymphocytes were cultured with RPMI 1640 medium plus 10% fetal bovine serum, in the presence of phytohemagglutinin to stimulate T lymphocytes and TPA to stimulate B lymphocytes. The amount of bromodeaoxyuridine added to the culture medium was 5 mg/ml. After a culture period of 46 hours, the cells were exposed to colcemid (0.1 µg/mL) for 2 hours at a temperature of 37 °C and a CO2 concentration of 5% in a humidified atmosphere in order to stop the cell division in metaphase. Once the cells were collected, they were centrifuged for 7 minutes at 2:00 p.m. at room temperature. The supernatant was removed and the cell pellet was immersed in a warm (37 °C) solution of 0.075 M potassium chloride. It was then incubated for 20 min in a water bath at 37 °C.

2Chromosomal and telomeric aberrations were examined in T and B lymphocytes in this study. Before and 24 hours after analysis, peripheral blood lymphocytes were cultured with RPMI 1640 medium plus 10% fetal bovine serum, in the presence of phytohemagglutinin to stimulate T

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Approximately five drops of fixative were added to 4each tube with shaking, and then the tubes were centrifuged for 7 minutes at a speed of 1400 rpm at room temperature. The cells were suspended in the fixative solution after removing the supernatant and then centrifuged using the same parameters. After two additional fixation cycles, the cells were kept in the fixative solution at a temperature of 4 °C overnight, and then the metaphases were dispersed on cold, wet slides the next day. The slides were dried overnight at room temperature and stored at -20 °C until further use. As mentioned previously (De González *et al*., 2004) [12], telomeres and centromeres were stained using a Cy-3-specific PNA probe from TTAGGG for telomeres and a FITC-labeled probe specific for centromere sequences. as mentioned before (De González *et al*., 2004) [12]. After being rinsed three times with PBS, they were treated with pepsin (0.5 mg/ml) at a temperature of 37 °C for 5 minutes. Then, the slides were dehydrated successively with 50%, 70%, and 100% ethanol and then air dried. The slides were added to the telomere and centromere probes, then they were denatured on a hot plate at 80 °C for 3 minutes, and then they were incubated in the dark for 1 hour at room temperature. Subsequently, the slides were rinsed three times with 70% formamide/10 mM Tris, pH 7.2, for 15 minutes and then with 50 mM. After the final rinse in PBS, the slides were stained with DAPI and placed in PPD with adequate pH. Automatic metaphase capture was performed by staining telomeres and centromeres.

Results

Demographic Results

A quantitative study was carried out for data collection and the results of the CT scans performed are reported (Table 2) indicating the demographic parameters of the patients.

Table 2: Patient demographics, organs scanned, average and maximum

	Descriptive parameters	
	Mean (SD)	**Min/max**
Type of examination		
AP with PC	18	8.8
AP Without PC	21	9.5
SKULL WCP	33	12.2
CRANE WCP	7.2	21.0
TAP WCP	23	10.0
TAP WCP	16	8.4
THORAX WCP	08	5.2%
THORAX WCP	10	8.8

Age is a very important characteristic to take into account when it is come to the types of exams performed. Examinations of the skull are the majority and those of other organs are between 7.2 and 33 years of age. Boys (55.3%) underwent more CT scans than girls (44.7%) [10], a mean of 31.6 and a standard deviation of 12.3 are observed. Cranial scans were performed more frequently (37.2%). Mfilou hospital was performed the highest number of scans (51.7%), followed by HCA (27.5%), Netcare and Talangai were received 17.2% and 3.6% of CT scans respectively.

Table 3: Patient demographics

Settings Descriptions		
AGE (ans)	**Mean**	**Min-max**
	41.596 (22.284)	0 à 85
X SEX	Absolute frequency	Relative frequency (%)
F	198	44.7
M	245	55.3
Type D'examen		
AP APC	48	10.8
AP SPC	51	11.5
C CRANE APC	63	14.2
TAP APC	102	23.0
T TAP APC	53	12.0
T AP SPC	46	10.4
Thorax APC	32	7.2%
Thorax SPC	48	10.8
Services		
HCA	122	27.5
Mfilou	229	51.7
Netcare	76	17.2
Talangai	16	3.6%

Table 4: PDL (mGy.cm)

PDL Center Skull spc Crâne apc Thorax spc Thorax apc AP spc AP apc TAP spc TAP apc
A 2494,35 5114,05 715,3 1936,4 1565,1 2904,6 1687,1 2780 B 613,895 1352,8 828,49 1855,675 1574,28 2073,865 1002,385 2720,845
Median A 2254,2 4260,1 689,7 1443 1220 2440,4 1400,6 2673,8 B 637,24 1354,11 160,01 1537,35 1138,69 2118,84 932,875 2610,22 Maximum A 2949,3 6017,7 827,63066 2546,5 3528 1973,6 3416,6 B 876,22 1959,12 911,85 2717,09 2128,64 2847,4 2600,18 3076,87

The injected doses corresponding to the time of [10] exposure of the organs to ionizing radiation were measured in pediatric patients according to the dose length of the product. In zones A, the center examination of the skull, TAP with contrast and the thorax, the duration of the examination is showed very high values of 5114.05 mGy.cm, 5045.47 mGy.cm and 3810.65 mGy.cm respectively. Other DLP values are being belowed 3000 mGy.cm in all centers.

The maximum PDL doses are being estimated at 6070

mGy.cm (Table 4) and the relative median is 4260 mGy.cm. The mean PDL values at the abdomen and pelvis are 1403.13 [12]mGy.cm and 2372.86 mGy.cm, both without and with contrast.

On the other hand, the median values are 1,133.03 mGy.cm and 2,233.14 mGy.cm, while in the thorax-abdomen-pelvis region the values are 1,532.61 mGy.cm and 3,515.44 mGy.cm, with medians of 1590.09 mGy.cm and 3423.17 mGy.cm. In centers B, the skull was received 2.57 mGy; 27.84 mGy in the Thorax and 29.03 mGy in the AP and up to 38.92 mGy in the PAC with contrast product. In contrast, the AP was received a dose of 29.96 mGy with contrast, while the TAP was received up to 70.64 mGy.

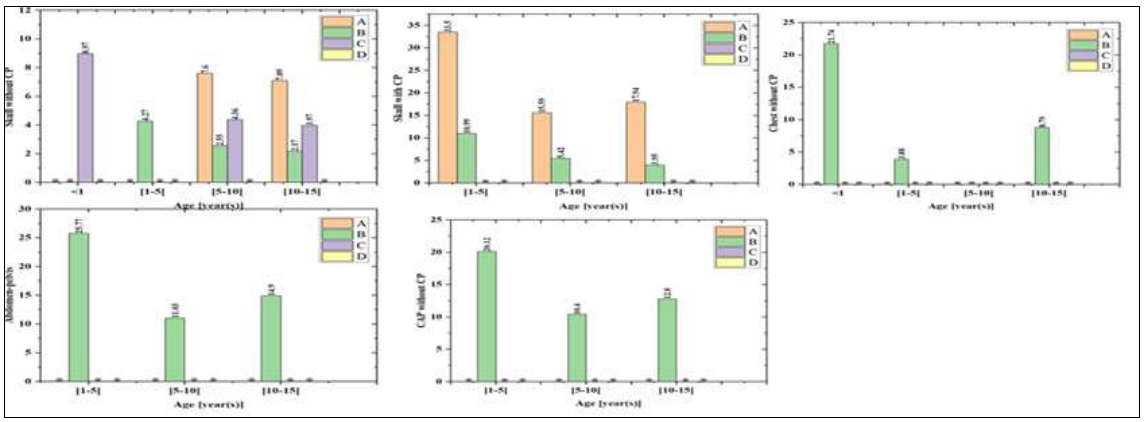


Fig 1: Pediatric CT Dose Index Volume

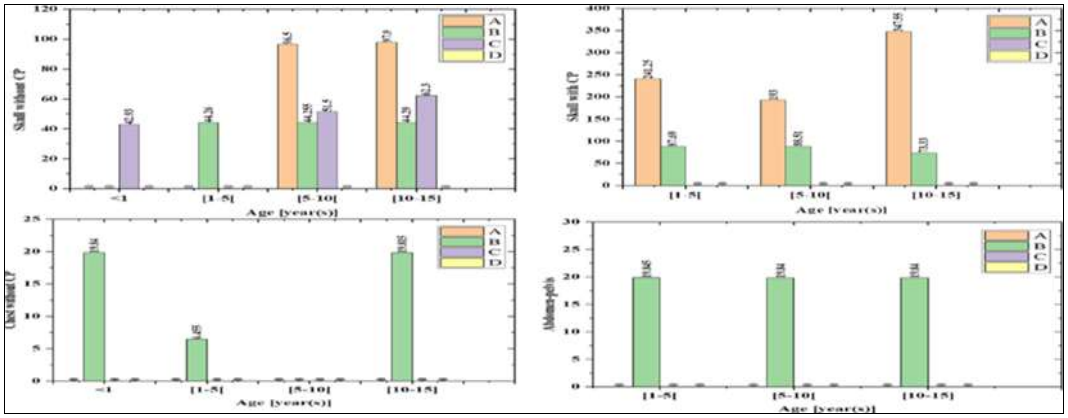


Fig 2: Pediatric Dose Length Products

Table 5: CTDIvol: Pediatric patients

Scan: year (s)	A	B
Cerebral without CP		
<1 an	/	/
[1-5[		4.27
[5-10[	7.6	2.55
[10-15]	7.09	2.17
Cerebral avec CP		
[1-5[	33.50	10.99
[5-10[	15.59	5.42
[10-15]	17.94	3.95

Comparison of effective doses in pediatrics in the two centers were compared to ICPR 60 in the literature (Dayton *et al.* 2018) [10]. The skull in pediatric patients in the age group [1.5] years and [5, 15] years were received the most effective doses (7.6 to 33.50mGy) in center A. For examinations of the thorax, abdomen-pelvis and CAP without contrast product, only center B was more effective for the injection of dose ranging from 21.74 mGy to 25.77 mGy and 20.12 mGy respectively (Table 5). On the other hand, center A was not carried out injections on pediatric patients, including those [1.5] years old at the level of the skull without contrast, but also at the level of the thorax, the AP and of TAP with and without contrast.

Table 6: Pediatric patient results

	A	B
Skull spc		
<1[5]	---	---
[1, 5[	---	4,27
[5, 10[	7,6	2,55
[10, 15]	7,09	2,17
Skull apc		
[1, 5[[5]	33,50	10,99
[5, 10[	15,59	5,42
[10, 15]	17,94	3,95
Thorax spc		
<1[5]	----	21,74
[1, 5[	---	3,88
[5, 10[	---	---
[10, 15]	----	8,79
Abdomino-pelvis		
[1, 5[[5]	----	25,77
[5, 10[	----	11,03
[10, 15]	----	---
TAP spc		
[1, 5[[5]	---	----
[5, 10[	---	---
[10, 15]	---	---

In contrast, CTDIvol (Table 6) in pediatric patients is shown very high effective doses in both pediatric age groups <1-5 years (19.84 mSv) in the chest. CTDIvol has been shown to underestimate the dose to larger organs for 30-48% CT coverage, depending on the conversion factor, and differs from were published data (European *et al.*, 2008) [16]. Abdominopelvic examinations with contrast material at center B are 4 times (25.77 mSv) higher than the American regulatory dose (Gao *et al.*, 2017) [17]. For pediatric patients was aged 1 to 5 years. In contrast, doses received without contrast material were moderately to 3 times (10.48 to 20.12 mSv) higher than normal data for the entire age group (Gao *et al.* 2017) [17]. Pediatric subjects was exposed in medical settings have been shown to suggest that cancer risk may be increased even at lower doses (Azin *et al.* 2018) [3]. In the skull, [13]effective doses in all centers are obtained using the ICRP 60 and ICRP 103 conversion factors (k), 15.98 mGy (A) and 4.13 mGy (B) similar facts are also observed while in the thorax doses of up to 53.35 mGy. cm are recorded, in the AP the doses are higher than those were recommended in Europe, reaching 67.07 mGy in A, 53.13 mGy in B. While at CAP, doses are higher than normal in all hospitals; in A (67.01 mGy) was compared to 53.13 mGy in B (Genesca *et al*., 2006) [18]. According to Gilson *et al*. (2007) [19], these cumulative doses of approximately 50 mGy given to children have been shown to gradually increase the risk of leukemia, while doses of approximately 60 mGy could triple the risk of brain cancer.

Table 7: Pediatric patient outcomes

	A	B
Crâne spc		
<1[5]	---	---
[1, 5]	---	44, 26
[5, 10]	96,5	44, 255
[10, 15]	97,9	44, 29
Crâne apc		
[1, 5][5]	241,25	87, 69
[5, 10]	193	88, 51
[10, 15]	347,55	73, 33
Thorax spc		
<1[5]	----	19, 84
[1, 5]	---	6, 455
[5, 10]	----	---
[10, 15]	----	19, 815
Adomino-pelvis spc		
[1, 5][5]	----	19, 845
[5, 10]	----	19, 84
[10, 15]	----	19, 84

The 1 to 15 year old age group in Centers A and B received the highest effective volumes in the skull scan, including children under 1 year of age (Table 7). At Center A, patients received the highest doses up to 97.9 mSv (5–15 years) to the skull. All pediatric age groups at Center B received the highest CTDIvol doses in the thorax and abdomen-pelvis only, with doses up to 19.84 mSv. Therefore, volumes that would allow assessment of effective doses in pediatric patients have not been evaluated. In pediatric patients at all centers, LDP values (Figure 9) in the skull without contrast medium in those under 5 years of age received doses up to 44 mGy.cm compared to 241.25 mGy.cm with contrast medium. The mean PDL values in the 5-10 year old group were 64.09 mGy.cm without contrast and 140.76 mGy.cm with contrast. In the 10-15 year age group, without contrast medium, 6816 mGy.cm and with contrast medium, with an average of 210.44 mGy.cm. At the thorax, abdomen and pelvis without contrast, all values were below 20 mGy.cm, while children under 5 years old received 6.46 mGy.cm at the thorax. This is explained by the non-regulation of doses administered to patients.

-Distribution of the dose delivered by scanner:

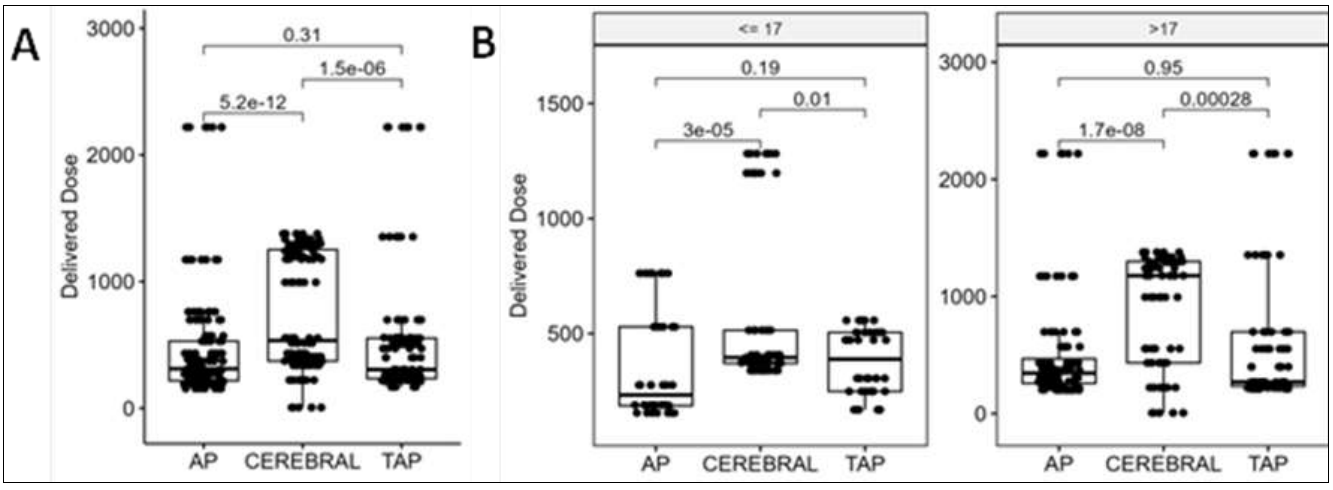


Fig 3: Shows the distribution of DPL and CTDI provided by CT-Scan.

The doses calculated with or without contrast material are not significantly different between DPL and CTDI delivered by CT-Scan, as illustrated in Figure 3. However, there is a notable disparity in the doses administered depending on the type of scanner used. Children were treated with a reduced dose.

[1]After the scan, the hematological parameters changed

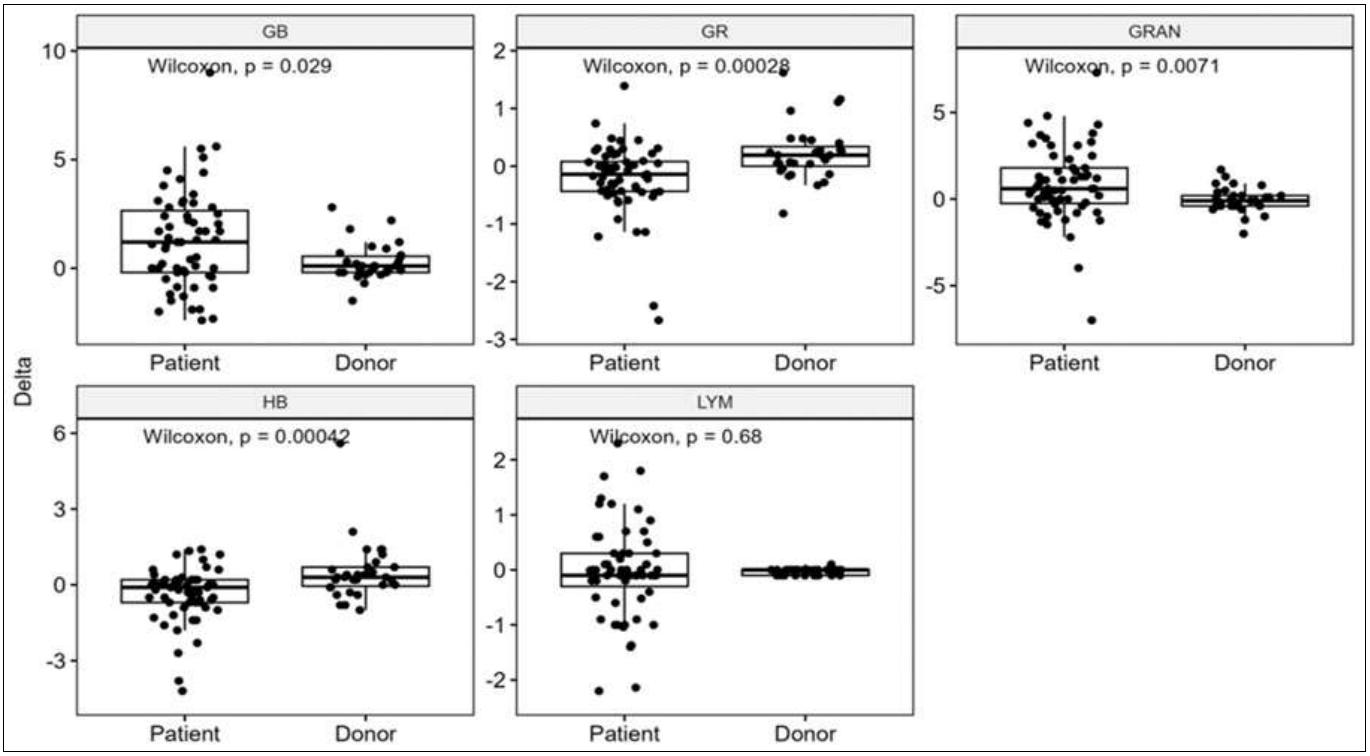


Fig 4: Distribution of lymphocyte levels in patients and respondents.

The variation in hematological parameters in patients after 24 hours of exposure to CT-Scan compared to the control population sampled under the same conditions is illustrated in Figure 4.

All patients showed a significant drop in red blood cells and hemoglobin compared to controls (p = 0.00028 and p = 0.00042). However, patients showed a notable increase in white blood cells and granulocytes compared to controls (p = 0.029 and p = 0.0071). Furthermore, there were no notable disparities in lymphocyte counts between patients and controls. However, a greater disparity between individuals was noted.

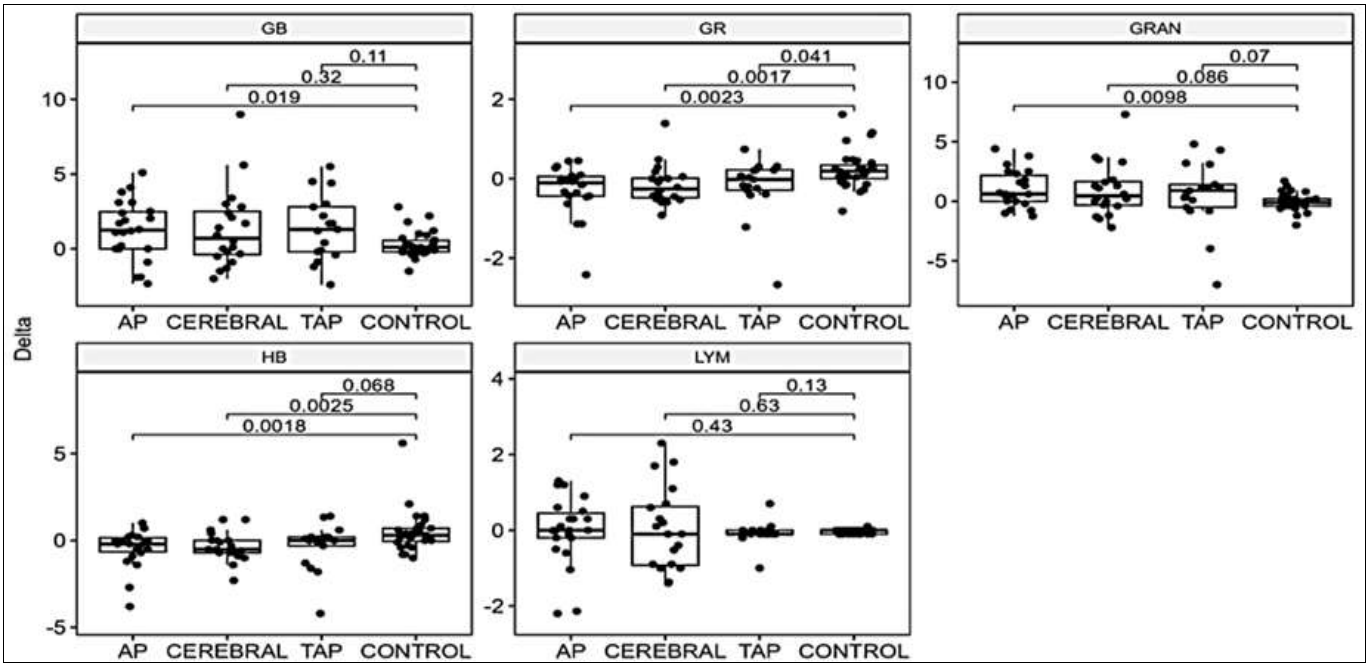


Fig 5: Interaction between the choice of scanner and fluctuations in blood parameters.

Subsequently, Figure 5 illustrates the relationship between the choice of scanner and fluctuations in blood parameters.

After various scanning techniques, a noticeable drop in red blood cells and hemoglobin is observed. A similar correlation was found between increased granulocytes and all CT scan types. However, [1]there was only a significant correlation between AP CT Scan and white blood. Before and 24 hours after CT scanning, an increase in the frequency of unstable chromosomal aberrations is observed in circulating lymphocytes of non-cancer patients. On a également effectué une analyse des aberrations chromosomiques instables dans les lymphocytes circulants provenant de donneurs sains d'âge et d'origine ethnique similaires. Les résultats concernant les aberrations chromosomiques ont été obtenus chez les patients avant et après la tomodensitométrie, tandis que dans le groupe témoin, certaines des aberrations typiques liées aux lymphocytes circulants ont été observées (Figure 6). Before CT scanning, no dicentric chromosomes were detected in the circulating lymphocytes of the patients, nor in the control group.

Following the CT scan, there was a notable increase in the number of dicentric chromosomes, but this increase was significant. It should be emphasized that radial formations were detected after CT scanning in B lymphocytes. After the scan, the frequency was significantly higher than previously observed. However, the most common chromosomal aberrations found after CT scanning were chromosomal acentrity and chromosomal disparity.

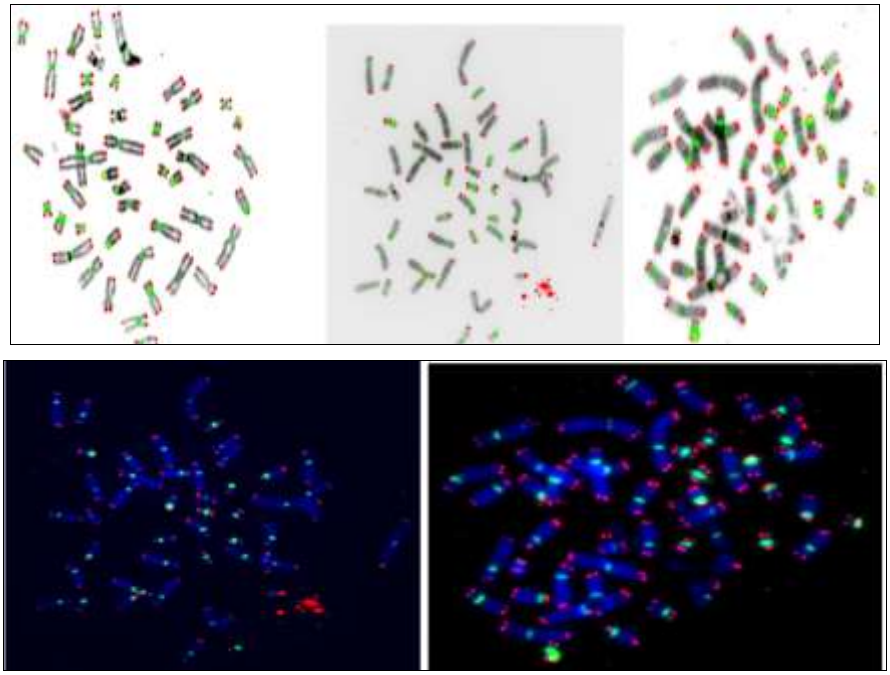


Fig 6: Images showing chromosome acentrity and deletion.

Considering all chromosomal abnormalities caused by the calculation of DSBs, we observe a significant increase in the frequency of total DSBs after scanning compared to that estimated before scanning in B and T lymphocytes (p < 2.2, 10-16 and p< 2.0210-8) (Figure 7).

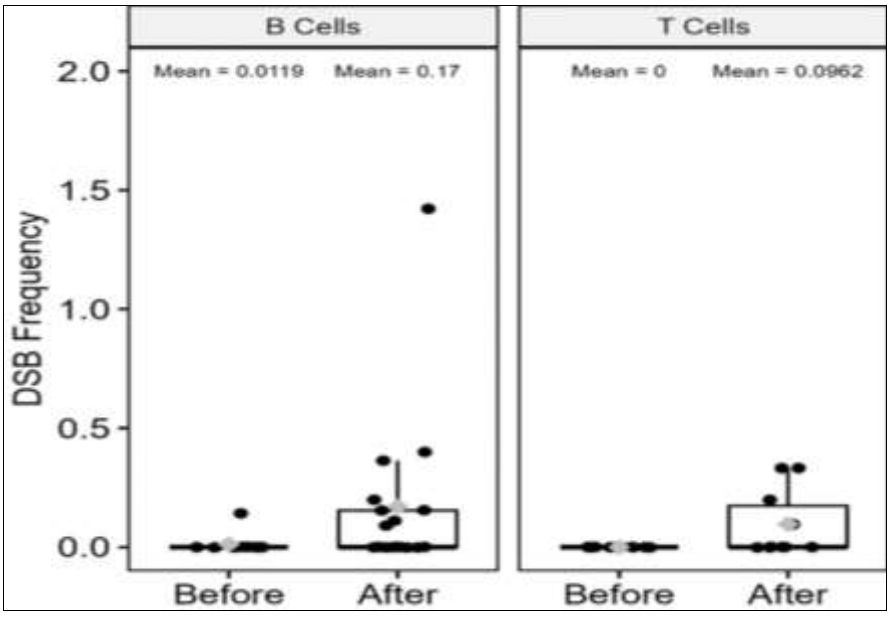
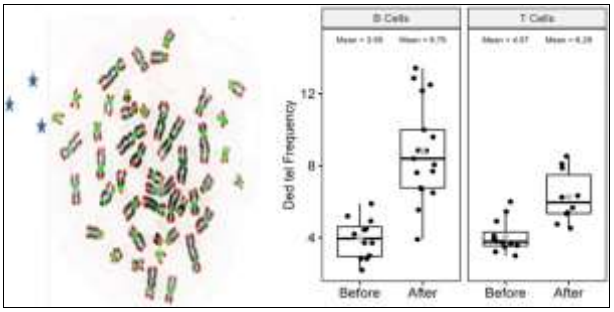


Fig 7: The total frequency of DSBs before and after scanning in B and T lymphocytes

[2] Chromosomal aberrations caused by the CT scan were significantly more common in B cells than in T cells. The presence of a functional telomere resolved the structural telomere aberrations, leading to chromosomal instability. We examined telomere shrinkage and telomere doublet creation before and after scanner exposure in this study. It is important to emphasize that the elimination of telomeres is perceived as a DSB and that their frequency was included in the estimation of the overall DBS. Following CT scanning, B and T lymphocytes exhibited significantly greater telomere loss than observed before exposure to the scanner (Figure 7).



[7]Telomere doublet formation after CT scanning was observed similar to that observed before CT exposure (Figure 8).

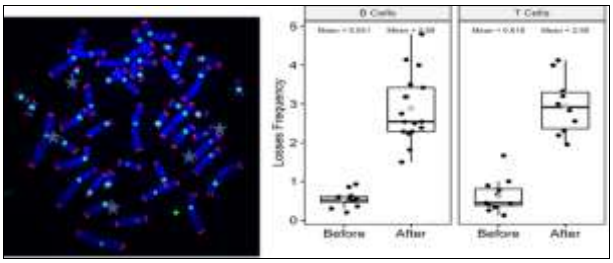


Fig 8: Formation of telomere doublets following CT scanning.

[1]Importantly, the percentage of telomere doublets in B cells was significantly higher than that observed in T cells ($p <$ 10-3).

The formation of chromosomal aberrations after CT scanning can be influenced by various factors such as age, gender, administered dose and changes in hematological parameters.

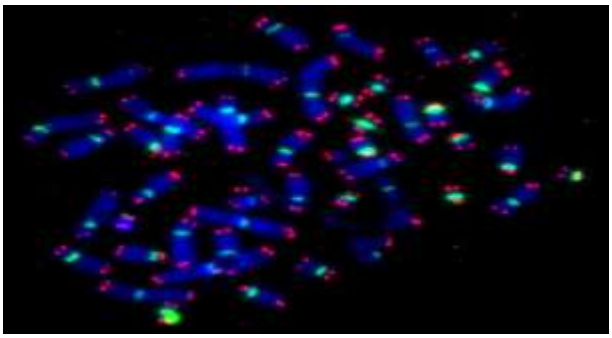


Fig 9: Image capture of 100 Metaphases

Discussions

Doses of ionizing irradiation were delivered to pediatric patients during CT examinations cause various effects on exposed tissues and organs. These effects can be caused various risks, including cancer. The doses administered are regulated in relation to international standards. Pediatric patients were received doses ranging from 193.00 to 347.55 mGy.cm to the skull at Hospital A. In the age group <1-15 years, all centers were received from 6.46 to 19.84 mGy.cm while the other organs were received between 39.58 and 73.81 mSv. In pediatric patients, CTDIvol is reached 347.55 mSv in the contrast-enhanced skull and other organs were received up to 19.84 mSv. [1] The research carried out showed that the doses administered to patients during CT scans in the Republic of Congo all exceed the standard. This is due to the non-regulation of doses administered to patients, the obsolescence of the equipment used and the lack of technical training of technicians and radiologists on dose reduction. These findings were sound the alarm to establish dose level reduction and a national regulatory body to convene international standards on dose reduction across the country.

The doses of contrast agents administered during CT examinations were carried out in two hospitals in the Republic of Congo Brazzaville on pediatric patients provide an idea of the management and care of patients before CT examinations. At center B, the doses is relatively high (5.24 mSv to 10.74 mSv) compared to the ICRP 60 and ICRP 103 standards in the literature. These values are 2 to 5 times higher than those of the International Convention on Reference Materials at dose 60, in centers A and B respectively. These high doses administered to patients were posed risk and exposure to ionizing radiation-related illnesses over time. It has been demonstrated that these effects is had an impact on the modification of hematological factors and consequently were lead to malignant diseases, direct consequences of cancers. According to the dose-length product of patients' exposure to ionizing radiation during the examination, the doses administered were shown an average of 1417.12mGy.cm for the examination of the skull without contrast medium and 3018.45mGy.cm with contrast product. These average values are much higher than those already observed (Doudenkova *et al.*, 2015) [13] and even compared to that of the European DLR. The median values in the skull, without and with contrast and in the thorax also are had a higher mean with contrast compared to those in the literature. In the abdomen-pelvis, the mean PDL values without and with contrast medium and the medians on the one hand and in the thorax-abdomen-pelvis, on the other hand, all values are also higher than those of the examinations already reported (European *et al.*, 2018) [16]. In pediatric patients, our study reveals an alarming dose of DLP administered, which is 5 times higher at reference doses (D'adda *et al.*, 2003) [11] for children aged 1 to 15 years and 3 times higher than the conventional doses recommended in Malaysia. The skull with contrast material was presented moderate (B) and very high doses (13 times) compared to conventional doses (Gao *et al.*, 2017) [17] in the USA compared to 15 times in Malaysia for patients aged 1 to 15 years in the center A. At Center B, pediatric data for chest exams without contrast was shown that the highest values (21.71 mSv) were 16 times the norm for the age group (<1 year) and older or older less moderate for patients aged 5 to 10 years. Centers A was not received patients for thoracic and abdominopelvic examinations during our study period. Given the overuse of the dose and radio sensitivity in children, the associated risks may be concerned various

pathologies (Girinsky *et al.* 2015) [20].

Comparison of pediatric effective doses with the literature is shown fairly high doses compared to international standards (Beauvais-March *et al*., 2004) [4] for the thorax, abdomen-pelvis and CAP without contrast product. Only in center B were these services effective and the doses administered. On the other hand, centers A was not performed injections on pediatric patients, due to the lack of attention in these health establishments, including the skull of [1.5] years without contrast, but also thorax, AP and TAP with and without contrast. Likewise, the evaluation of the volume of actual doses delivered to patients, CTDIvol is shown that the actual doses delivered to adult patients in the skull, without contrast material in the two hospitals selected in this study, are all below the diagnostic reference level in CT scanning compared to the European Commission and the [19]American College of Radiology (Cristy *et al.* 1987) [9]. With contrast material, the values in the skull and center A, is represented the highest CTDIvol values of the two centers, with the average with the median of the contrast medium. This represents higher values compared to European standards (European *et al.*, 2018) [16]. However, chest exams, AP and TAP, with or without contrast medium, were shown very high values, which require training of radioprotection agents, in particular on dose reduction techniques as well as monitoring and evaluation, in pediatric patients. These weighted CT dose indices are represented the actual dose per patient and are all belowed the standard for protecting patients from the harmful effects of radiation without reducing diagnostic efficiency. In pediatric patients, the dose-length product values are higher in newborns (< 1 year) with 2.1 and 0.7 in adolescents, in the skull we are reached the PDL value up to 347.55 mGy.cm in adolescents aged 10-15 years, showing future risks. Given the very low dose administered, the age range of pediatric patients and their vulnerability on the one hand, and the fragility of pediatric patients on the other hand, are demonstrated that the procedure and optimization parameters can be played an essential role in dose delivery, which is not necessarily correlated to intrinsic factors of the device used. It is not only the obsolescence or poor practice of the equipment used, but also the quality of the execution that must be considered. The reason for overdoses in some cases could be reflected the quality of personnel involved in the use of laboratory equipment and the risks of associated cancer diseases. By comparing the effective doses between hospital settings, we are seen that the values obtained can be influenced by the quality of the equipment and the quality of the technical staff, already questioned in Congo (Hernandez *et al.* 2015) [22].

Administration of such high doses to pediatric patients in all CT scans clearly demonstrates a potential danger associated with multiple cancer risks.

Furthermore, according to the basic principles of radiation protection, in all cases, each party with responsibilities, particularly in terms of safety, must be ensured that the relevant requirements are applied, and ensured that specific dose limits are not exceeded. These alarming doses should be prompt local authorities to take the necessary measures to prevent patients from being exposed to overdoses of contrast media and, consequently, ionizing radiation. Prescribing a CT scan for children is a common medical procedure these days. Its implementation at the Yalgado Ouédraogo hospital is carried out with considerable inadequacy in terms of pediatric radiation protection. The results were shown that the doses delivered when performing abdominopelvic CT in the pediatric age group induce chromosomal aberrations in peripheral circulating lymphocytes. In addition to the dicentric chromosomes, the rings and there is a strong accumulation of acentric chromosomes. The appearance of these chromosomal aberrations is closely correlated with the exposure doses during examination procedures. Indeed, the calculated effective doses are significantly higher than the ICRP60 standards; CIPR103 and at the reference dose of. Several factors are attributable to the increase in the dose delivered to children. The absence of a diagnostic reference level at the national level, the use of adult parameters for children's CT scans, absence of procedures for performing CT scans for children, the lack and insufficiency of quality control of equipment and the insufficient training of practitioners and prescribers in pediatric radiation protection. To this end, it would be appropriated to recognize the limitations of this study in that we were not had all the necessary equipment for more in-depth measurements of the doses delivered by the scanner. However, this test was simply revealed that after an abdominopelvic CT carried out under hospital working conditions where the dose delivered is sufficiently high to produce unstable chromosomal aberrations for the pediatric age group. [14] This makes a real contribution to understanding the radiation-induced impact of low doses, particularly in the area of young children. Finally, compliance with patient radiation protection rules should be helped protect this segment of the population from the probable carcinogenic effects of low doses. Furthermore, (Ducray *et al*., 1999) [14] were shown that adequate diagnostic information can be obtained at lower doses.

[1]Human cells and volunteer patient tissues can be negatively impacted by prolonged low-dose ionizing radiation exposure, especially the quantity of peripheral blood cells.

It is widely believed that the effects of ionizing radiation on blood cells, which have been well-documented, play a role in the development of hematopoietic syndrome. This syndrome has been found in both patients and case/control participants after total body irradiation (Billings *et al.*, 2014) [5]. In some job conditions, it is inevitable to be exposed to low levels of infrared radiation. Radiological mishaps will surely persist, even if they are regrettable at best and disastrous at worst. Thankfully, the majority of radiation exposures only involve modest doses (<1 Gy), therefore no instant death occurs. Nonetheless, it is important to give careful thought to the potential long-term effects of low-dose exposures. White blood cells seemed to be the most sensitive to X-ray irradiation among the cell types studied, based on the severity of the decline and the time necessary to reveal a significant fall in blood cell counts following irradiation (Sanzari *et al.* 2014) [35]. [16] Blood cell counts significantly decrease as a result of IR damage[1] in a dose-dependent way, which raises the possibility of health risks. Long-term exposure to low doses of ionizing radiation has been shown to impact cells and tissues, resulting in a decline in blood counts soon after irradiation and recovery in a few weeks (Rozgaj *et al*., 1999) [33]. According to a study by (Seed *et al.* 2002), IR is one of the cytotoxic agents that specifically harms cell renewal mechanisms. Additionally, it was revealed that, in accordance with cumulative radiation doses, neutrophil lymphocytes and granulocytes consistently displayed an early reduction in the first few days. To sustain

cellular replication and system homeostasis, a proliferating cellular system needs an intact cell type, the stem cell, and early progenitor cells. All cells can be impacted by radiation, whether it be acute or chronic; among the most radiosensitive cells are stem cells and early progenitor cells. As would be predicted from a damaged cell, hundreds of clones of stem and progenitor cells can arise with individual damage at comparatively low doses or dosage rates. As a result, several cell clones would nourish a diverse range of proliferating cells, potentially leading to aberrant cell [1]populations (Kutkov *et al.* 2011) [26]. The idea that certain stem cell subpopulations are mostly immune to radiation-induced damage is supported by the extraordinary degree of variation in bone marrow cell type, proliferation potential, and cell cycle state [1] (Grande *et al*., 2000) [21].

In the current investigation, the white blood cell count began to be impacted at the dose of 0–3 Gy and a substantial decrease was seen 24 hours after irradiation at all dose levels in comparison to the control group. As the dosage increases, the magnitude increases as well. This outcome was similar to that of Thrall *et al*., who found a statistically significant decrease in the leukocyte count [1]. 24 hours following radiation therapy for all patients, save those[1]in the 0.25 Gy Group. The most common cause of death following unintentional or deliberate exposure to moderate to high levels of ionizing radiation is damage to hematopoietic stem cells. Radiation exposure can be damaged hematopoietic stem cells and generate numerous forms of free radicals in live cells. The apoptosis of hematopoietic cells can be brought on by these reactive oxygen free radicals, which will reduce the cells' capacity for proliferation. The hematopoietic system is one of the most radiosensitive systems, hence this is highly likely to happen. Blood clots for complete blood arteries are likewise supplied by this mechanism (De González *et al.,* 2004) [12]. [9] The hematological characteristics of patients exposed to radiation, with the exception of **[1]** Monocytes and red blood cells are particularly vulnerable to the effects of radiation and are rapidly altered. For instance, stem cells are extremely radiosensitive, even though adult platelets are less sensitive to ionizing radiation. Patients' platelet counts are subsequently lower than those of case/control subjects. In general, platelet counts drop five to ten days following exposure to a mild or moderate dose of infrared radiation. The amount of IR administered and the use of platelets are directly connected to the length of thrombocytopenia [3]. at locations where there is current bleeding as a result of non-hematologic IR exposure sequelae, such as trauma or gastrointestinal injury. A paper that was given states that there was a post-irradiation decrease in platelet count, particularly at 0.5 Gy, but that this decrease was not statistically significant when compared to the control. However, there was no discernible difference in the platelet count between the first and second day of irradiation and the control for the other administered dosages. Furthermore, as the irradiation dose is increased, there is a discernible decrease [1]in both the degradation and recovery rates, which happen simultaneously. Red blood cells don't react to radiation very strongly. (Wirth-Dzie *et al.,* 2009) [37] [1]revealed that there were notable variations in the hemoglobin and red blood cell counts among juvenile patients. However, it was discovered by (Sanzari *et al*. 2014) [35] that there was no statistically significant difference in the number of peripheral hematopoietic cells between the outcomes after patients were exposed to [1]low dosage rates of radiation.

It was observed in this study that RBCs gradually increased with increasing IR dose until reaching 0.5 Gy, then they started to decrease until reaching 0.5 Gy. 1 Three hours after radiation, the dose of 0.5 Gy produced the highest value of RBCs. Then, as time passes, the quantity of red blood cells decreases exponentially. Conversely, it was observed by Nunia *et al.* (2004) [31] that there was a substantial ($p<$ 0.001) drop in the total red blood cell count at all radiation dose levels during the experiment. Furthermore, there was a significant ($p<$ 0.001) decrease in radiation exposure.[3] the myeloid/erythroid ratio was elevated, but not the number of normoblasts in the bone marrow, red blood cell count, hemoglobin, hematocrit, or erythropoietin levels in the blood.[1] Therefore, a computational dosimetry system and a dose-length product in a scanner are used to determine the effective radiation dose, and the frequency of these aberrations is compared to that amount.[1]Subsequently, the analysis results indicate a noteworthy rise in telomere abnormalities subsequent to the scanner exposure. Nevertheless, no relationship has been found between the incidence of chromosomal and telomeric abnormalities and the effective radiation dosage. It is significant to remember that chromosomal and telomeric abnormalities increased with age. **[1]** In addition to telomere shortening, patients also exhibit telomeric aberrations during scanner exposure, and their telomere loss and/or ratio of short telomeres is lower [2] a more accurate diagnostic method for identifying damaged cells than telomere length measures. The persistence of chromosomal instability is mostly due to this lack of telomere functioning. When all chromosomal abnormalities are taken into account for DSB computation, the frequency of total DSBs following scanning is much higher than the expected frequency before to scanning in B and T cells ($p<$2.2 10-16 and $p<$2 02 10-8) [2].d B and T cells are susceptible to telomere dysfunction, which can also impair chromosomal pairing and result in recombination errors. The end effect of these occurrences will be extremely low frequency of unstable chromosomal abnormalities. As a logical next step, we examined telomere shortening and aberrations in patients using circulating lymphocytes as part of the routine test for chromosomal abnormalities, which is employed in the treatment of these patients.[2] Telomere length from a control group that ranged in age from 14 to 17 years was quantified, and the results showed that telomere length decreased at a rate of 79 base pairs per year and was age dependant.

This telomere shortening [2]can be increased by radiation-induced telomeric damage, which prevents telomeres from being maintained, or by exposure to ionizing radiation. The last two scenarios involve an increase in cell proliferation intended to replace dead cells following exposure. Continued exposure to various endogenous and external DNA-damaging agents throughout the cell's life will extend accelerated telomere shortening (d'Adda *et al.,* 2003) [11]; (Lin *et al.*, 2012) [27]; Price *et al.*, 2013) [32]. Considering that variation in telomere length on each arm of individual chromosomes is maintained throughout telomeric shortening in each cell cycle, the shortest telomeres will be eventually become crucial and dysfunctional. These damaged or dysfunctional telomeres are recognized as DNA damage in normal cells with intact cell cycle checkpoints; DNA damage response mechanisms are triggered, resulting in the

formation of TIFs (Takai *et al.*, 2003) [36]. According to a significant study, normal human cells can tolerate a limited number of defective telomeres and keep growing until five TIFs are present in each cell. This threshold of five defective telomeres causes senescence or apoptosis in normal cells with intact cell cycle checkpoints. Since immortalized cells lack cell cycle checkpoint proteins, they are unable to undergo senescence. [1] When senescence is momentarily evaded, cells multiply and accumulate chromosomal instabilities, TIFs, and telomeric shortening, culminating in a "telomeric crisis." More than five dysfunctional telomeres were discovered in cells going through this crisis (Kaul *et al.*, 2012) [25], along with extensive chromosome fusion and cell death (Counter *et al.*, 1994) [6], most likely as a result of extreme telomere shortening and shelterin protein loss. We were informed that while the carcinogenesis process was halted, the increased risk of diseases associated with cell death was caused by this cell death brought on by "too much" genetic instability. Ionizing radiation exposure also causes a number of additional cellular and DNA damage, the most prominent of which being double-strand breaks and mitochondrial malfunction. Chromosomal abnormalities can result from double-strand breaks in DNA. Signals of stress that might be sent to the offspring of irradiated cells, as well as to non-irradiated cells and their progeny, resulting in ongoing oxidative stress, extended cellular harm, and the spread of genomic instability; telomeres may have contributed to the chromosomal instability's long-term transmission (Shim *et al.*, 2014) [34]

Individual differences between individuals 1 Age, sex, the intrinsic lengths of telomeres and the radiation-induced alterations to them are all potential factors in radiosensitivity, which is evaluated in terms of radiation-induced double-strand breaks. Furthermore, simpler genomic damage might result from radiation-induced mitochondrial malfunction caused by excess reactive oxygen species. [2]Thus, genomic instability may be made worse by prolonged oxidative stress (Shim *et al.*, 2014) [34]. Since the dysfunction of telomeres can lead to and spread genetic instability and heterozygosity loss, all of these issues may also be related to telomere dysfunction. [1] Telomeres can therefore be regarded as important components [2]in the process of radiation-induced illnesses. According to Shim *et al.* (2014) [34], telomeres are a good candidate as a predictive biomarker due to a number of their properties and the mechanisms that support them. According to a recent paper (Mirjolet *et al.*, 2015) [28], telomeres and their upkeep have the capacity to forecast an individual's radiosensitivity, which can be used to customize radiation regimens. Telomere length varies across persons and within the same individual, including within a same cell. These are the main arguments in favor of telomeres as a predictive biomarker of individual radiosensitivity. In somatic proliferative tissues, telomere length naturally shortens with aging and with each round of cell replication. Endogenous variables as well as external environmental and lifestyle stressors that result in inadequate telomere replication or DNA double-strand breaks can increase natural telomere shortening. Thus, telomere length can be viewed as a predictive indicator that considers the entirety of past experiences. Reduced telomere length has been linked to a number of chronic diseases and is a reflection of the accumulation of prior insults from various harmful situations. such as diabetes, cancer, and heart disease, which are often [8]regarded as diseases (M'Kacher *et al.*, 2015) [30] According to [2](Armanios *et al.* 2012) [1]; (Holohan *et al.* 2014) [23], abnormal telomerase activity and regulation of telomere length have also been linked to the pathophysiology of a number of age-related human disorders. Approximately 85% of human malignancies have elevated levels of telomerase, indicating a significant function for this protein in the processes of cellular immortalization and carcinogenesis. It has been demonstrated that telomeres and the processes that maintain them have a significant impact on the onset, progression, and aftereffects of cancer and other human diseases.

Perhaps as a result of improper processing, telomeric areas are more vulnerable to oxidative stress brought on by radiation and are more likely to experience DNA double strand breaks:

Telomere shortening or loss results from telomere replication being hampered by DNA damage present in telomeric regions. Chromosome instability linked to human cancers has been proposed to be influenced by poor repair of DNA double-strand breaks around telomeres. Because of this, telomeres are more vulnerable to radiotherapy and ionizing radiation exposure than the rest of the genome. DNA damage repair mechanisms and telomeres are linked in a bidirectional and co-dependent manner. Since DNA damage repair processes are triggered by defective telomeres, which are known to be double-strand breaks, these pathways' proteins are also involved in the maintenance and protection of telomeres. Telomere maintenance may be intimately related to radiosensitivity, given the close relationship between DNA damage repair processes and radiosensitivity. Based on all of the available data, telomere preservation and sensitivity may be novel biomarkers of ionizing radiation exposure and a new way to predict an individual's radiosensitivity (Shim *et al.*, 2014; Mirjolet *et al.*, 2015) [34, 28]. As we discovered with TC-FISH analysis, the combination of intrinsic telomere length and their radiation-induced changes, as well as age and sex, might in fact predict radiosensitivity. [1]Considering everything mentioned above, it would be crucial if these variables could be modified in order to provide a clinical approach for identifying individuals who are radiosensitive. However, in the context of radiation, [1]TC-FISH study of telomere length to predict individual radiosensitivity may be helpful. [1]As (Mirjolet *et al.*, 2015) [28] point out, in the context of radiation therapy, the capacity to accurately forecast a patient's radiosensitivity may provide treatment customisation. [2]Generally speaking, a number of *in vivo* and *in vitro* investigations using telomerase-deficient mice and human cells have connected shortened telomere lengths with elevated radiosensitivity. It has been demonstrated that telomerase inhibition or down regulation reduces the viability of cancer cells while having minimal effects on healthy cells. As a result, cancer cells can be rendered more susceptible to treatment by using telomerase inhibitors during chemotherapy or radiation therapy. However, telomerase activity was found to be upregulated and telomere length was shown to be longer in radio resistant cancer cells (Genesca *et al.*, 2006; Ayouaz *et al.*, 2008; Shim *et al.*, 2014) [18, 2, 34].

The lengths of telomeres and shelterin proteins in cancer cells and normal cells are suggested by the authors to be employed in the context of customized radiation therapies based on individual radiosensitivity. Pharmacological

treatments that disrupt the biology of telomeres in tumor cells can be utilized to modify the doses per fraction, improving the safety and efficacy of radiation therapy.

Conclusions

The survey was carried out in two medical imaging departments including the characteristics of the equipment, such as model, [7]serial number, manufacturing year, installation year, and other pertinent data, is focused on two large military and civilian hospital structures in the Republic of Congo, namely: the Pierre MOBENGO Central Army Hospital (A), Banche Gomez (B) where the scanners were carried out to carry out examinations at the different sectors of the body according to the study. The purpose of [9]this study was to assess or estimate how children affected by low radiation doses from scanner exposure would fare. [1]Current epidemiological studies show that children and adolescents who receive low-dose ionizing radiation from diagnostic CT scans a cumulative dosage of about 50 mSv are at heightened risk of developing cancer. Our work has shown that CT scanning is a better technique used to evaluate the diagnostic reference level like many African countries, particularly in Congo Brazzaville where a total of 76 pediatric patients were the subject of a scan examination according to the selection criteria.[3]Since hematopoietic cells are extremely sensitive to radiation damage, even at relatively low exposure levels, it is crucial to comprehend how each symptom changes over time in response to gradually increasing radiation doses in order to fully comprehend the animal model. This initial investigation has aided in the assessment of how low-dose ionizing radiation affects specific blood components in patients [3]. It is advised that more research be done to determine other IR risks that radiation field workers may encounter. According to an analysis of the data gathered, patients received doses during CT exams [1]that were greater than usual, whether the contrast agent was injected or not. Therefore, the doses submitted to patients during CT Scan examinations are more exposed to ionizing radiation and urgent measures are taken to avoid long-term medical exposure to enable adequate patient care.

[3]Since hematopoietic cells are extremely sensitive to radiation damage, even at relatively low exposure levels, it is crucial to comprehend how each symptom changes over time in response to gradually rising radiation doses in order to fully comprehend the animal model.[2] There is a discernible rise in DSB following CT exposure due to all chromosomal abnormalities.

[1] It should be mentioned that chromosomal and telomeric aberration increases were depending on age.

[2] The persistence of chromosomal instability is mostly due to this lack of telomere functioning.

[2]According to scientific research, a diet high in whole grains, fruits, vegetables, dairy products, seafood, algae, and coffee is favorably correlated with white blood cells' healthy telomere length.

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Conflict of Interest

Not available

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Not available

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