Cancer Incidence Risks to Patients due to Barium Meal and Barium Enema by Using Fluoroscopy.

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Abstract:

Background: The most common radiological tests of the GI tract are barium meal and barium enema, which are performed using conventional fluoroscopy and digital fluoroscopy, all of which result in high radiation doses to patients. And it is carries some risks like the other X-ray procedures. The object of this research is to estimation of effective dose and a Cancer incidence risk associated with barium meal and barium enema in some hospitals in Erbil City-Kurdistan region/Iraq.

Material & Material & Methods: The dosimetric survey was carried out on 120 patients. The procedures were performed by two equipments, the first was a Siemens unit which is a conventional fluoroscopy, and the second was Shimadzo which was a digital unit Beside BMI, patient exposures factors (mAs, kVp, exposure time, and air kerma) were measured. Organ doses, effective dose with per cent (%) of Risk of exposure-induced death (REID) were estimated by using PCXMC 2.0 software.

Results: The mean±S.D for DAP values found in the present study are 25.20±2.41 Gy.cm2 and 12.80±0.68 Gy.cm2 for BaMC and BaMD, respectively, with significant differences p= 0.001 And, 32.13±0.25 Gy.cm2 and 25.0±2.68 Gy.cm2 for BaEC and BaED, respectively with significant differences p= 0.0001. the value of effective dose for BaMC and BaMD are (5.73±1.93,5.49±1.89)mSv and (2.72±1.22, 2.62±1.16)mSv, respectively. But for BaEC and BaED are (6.04±1.60, 7.07±1.86)mSv and (4.17±1.41, 4.90±1.63)mSv, respectively . The first and second values in the brackets correspond to the ICRP103 and ICRP60. The type of cancer received the high value of REID% for BaMC and BaMD is the Colon cancer (0.0128%, 0.069%) respectively, for male patients, but for female patients are Lung cancer (0.264%, 0.123%) respectively. Also, the high value of REID% for BaEC and BaED are the Colon cancer (0.283%, 0.174%) respectively, for male patients, but for female patients are the bladder cancer (0.275%, 0.183%) respectively

Conclusion: From this study concluded that digital systems give a lower dose-areaproduct than non-digital systems for both examinations BaM and BaE. Also, the DAP for BaE is higher than that recorded for BaM. The three organs that received higher dose in both examination and both system are the same (Stomach , Liver and Colon) Also, concluded that The REID% values for female patients were slightly higher than the corresponding values for males for both examination groups, and the REID% are higher from conventional procedure than that record for digital system.

Key Words: Fluoroscopy, Barium meal, Barium enema, Cancer Risk, Effective Dose.

Introductions:

Fluoroscopy is a type of medical imaging that shows a continuous Xray image on a monitor to be reviewed by the physicians. The image is projected to a screen so that the movement of a body part or an instrument or contrast agent through the body can be viewed in detail. Fluoroscopy is performed for diagnostic imaging purposes by the visualization of patient anatomy; for example, by viewing the gastrointestinal tract (GIT)[1,2]. Barium contrast examinations were the basic routine radiological examinations of the GIT, the most common is the Barium meal (BaM) which is the basic routine radiological examination of the stomach and duodenum involving the ingestion of barium sulphate contrast medium that coats the stomach and aids and its radiological examination. And the barium enema (BaE) which is the routine radiological examination of the colon where barium sulphate contrast medium is administered through the rectum and aids in radiological examination of the colon.[3] Radiological examination for BaM and BaE include a digital fluoroscopy and a conventional fluoroscopy, all of which result in high radiation doses to patients. And it is carries some risks like the other X-ray procedures [4]. The dose of radiation varies from patients to patients, depending on the individual procedure, patient size, exposure parameters such as kVp, mAs and time setting. Radiation-related hazards associated with fluoroscopy include radiation-caused injuries to the skin and underlying tissues which occur briefly after the exposure, and radiation-induced cancers [5]. During BaM and BaE examinations that utilizing by X-ray involves the exposure of sensitive organs of the body such as the thyroid, breasts and the reproductive organs [6]. Thereby necessitating the investigation of radiation doses associated with them. A convenient method for dose assessment, especially in dynamic procedures in which exposure parameters are continuously varying is measuring the dose–area product (DAP) [4].And estimation organ and effective doses are important quantities in relation to the assessment of radiation risk[7].This study aims to calculate the mean value of the organ and effective doses associated with BE and BM in some hospitals in Erbil City-Kurdistan region/Iraq, using the Monte Carlo PCXMC 2.0 code and estimate the radiation risk. In PCXMC lifetime risks are expressed in terms of risk of exposureinduced death (REID). For practical purposes, at typical dose levels encountered in X-ray diagnostics, REID and Lifetime attributable risks can be interpreted to present the excess radiation-induced cancer risk and their numerical values are close enough to be interpreted identical considering the uncertainties involved in the models [8 and 9].

Material and Methods: This study performed in two hospitals, Par Hospital (PH), and Rizgary Hospital (RH) in Erbil City-Kurdistan region / Iraq. The procedures were carried out 120 examinations a 30 patients who underwent BaM examinations and 30 patients who underwent BaE examinations by using conventional fluoroscopy (CF) system, also 30 patients who underwent BaM examinations, and 30 patients who underwent BaE examined by using digital fluoroscope (DF), were enrolled in the study. The Patient physical characteristics (age, height and weight and body mass index (BMI (kg/m2)) were recorded for all patients from December 2015 to December 2016. The procedures were performed by two equipment, the first was a Siemens unit (serial no.01327507, 2002), which is a conventional fluoroscopy, and the second was SHIMADZO (PN/SN 533- 244 85, 2012), which was a digital unit with automatic control. Barium sulphate for BaM and barium sulphiricum for BaE was used as contrast agents. The Air kerma as a measure of radiation dose, air kerma rat (mGy/sec), exposure time, kVp, mAs and the distance between the patients and X-ray source (SID) was determined for each radiographic and fluoroscopic exposure to each patient by using (NOMEX Multimeter). Also, dose area product DAP was measured with a transmission ionization chamber mounted on the collimator of the X-ray machine and connected to a read-out unit (PTW Diamentor, Freiburg, Germany). The organ doses and effective dose were estimated by using the PCXMC software version 2.0. Also Risk of exposure-induced death (REID%), which estimated for the cancer incidence were evaluated.

Results:

Table 1, show the distribution data of number of patients and percentage % of each group with Mean±S.D(Range) for weight (kg), height (cm) and BMI(kg/m2). We show that is no significant differences in age, Weight, height and BMI for BaMC and BaMD. And show the significant differences in age and Weight for two group of BaEC and BaED with value of p= 0.029 and 0.011, respectively. Table (2), show the Mean±S.D(Range) of exposure factors for kVp, mAs, Air-kerma(mGy), Air-kerma-Rate(mGy/sec) and Exposure Time(min.), We seen there are no significant different between the groups BaMC and BaMD for Air kerma (mGy), but there are a significant different between this two group for kVp with p=0.0001, mAs with p=0.0001 , Air kerma Rate (mGy/sec) p=0.001 and fluoroscopy time(min) p=0.0001. Also, there are a significant different between the BaEC and BaED groups for kVp p=0.0001 and Fluoroscopy Time (min.) p=0.0001. Table (3), show the Mean±S.D (Range) for Dose area product DAP (Gy.cm2), Organs Dose (mGy) And Effective dose (mSv). The dose areaproduct DAP for patients underwent BaM and BaE or other fluoroscopy procedure should be established to optimize patient dose, to compare with other studies and to review regularly. The mean±S.D for DAP values found in the present study are 25.20±2.41 Gy.cm2 and 12.80±0.68 Gy.cm2 for BaMC and BaMD, respectively, with significant differences p= 0.001 And, 32.13±0.25 Gy.cm2 and 25.0±2.68 Gy.cm2 for BaEC and BaED, respectively with significant differences p= 0.0001. Organs that receive relatively high doses for BaMC and BaMD are the Stomach, Liver and Colon with value (18.54±6.17, 12.34±4.16 and 7.75±3.04)mGy and (9.17±3.86, 5.70±2.40 and 4.15±1.74)mGy, respectively. But the organ that receive relatively high doses for BaEC and BaED are the colon, Stomach and Liver with value (17.07±4.46, 7.34±2.61 and 2.93±1.24)mGy and (10.50±3.75, 6.34±2.47 and 3.02±1.36)mGy, respectively. Effective dose is a good quantity to express biological risk [18, 19], from Table 3, we note that the value of effective dose for BaMC and BaMD are (5.73±1.93,5.49±1.89)mSv and (2.72±1.22, 2.62±1.16)mSv, respectively. But for BaEC and BaED are (6.04±1.60, 7.07±1.86)mSv and (4.17±1.41, 4.90±1.63)mSv, respectively . The first and second values in the brackets correspond to the ICRP103 and ICRP60. Figure (1) and (2), Present the cancer risks from the BaM and BaE procedures. Show that the first, second and third types of cancer received the high value of REID% for BaMC and BaMD are the Colon cancer (0.0128%, 0.069), Stomach cancer (0.125, 0.0618) and Lung cancer (0.0125, 0.0581) respectively, for male patients, but for female patients are Lung cancer (0.264%, 0.123), stomach cancer (0.167%, 0.0831%) and colon cancer (0.0825%, 0.0444%) respectively. Also, the high value of REID% for BaEC and BaED are the Colon cancer (0.283%, 0.174%), Bladder cancer (0.213%, 0.143%) and Stomach cancer (0.0493%, 0.0427%) respectively, for male patients, but for female patients are the bladder cancer (0.275%, 0.183%), colon cancer (0.182%, 0.112%) and ovary cancer (0.085%, 0.057%) respectively.

Table (1): The Distribution of Number, % and Mean±S.D(range) for Weight (kg), Height (cm) and BMI (kg/m^2) with P-value.

Group	No.	%	Age	Weight (Kg)	Height (cm)	BMI (Kg/m^2)
BaMC	15	50.0	38.4±13.7 (17-65)	76.0±10.8 (58-98)	1.62±0.06 (1.45-1.75)	28.98±4.71 (21.30-39.96)
BaMD	15	50.0	45.0±13.9 (18-65)	80.8±10.1 (60-99)	1.64±0.07 (1.54-1.79)	30.18±4.79 (22.02-40.68)
P-value			0.069	0.079	0.299	0.333
BaEC	15	50.0	44.6±14.6 (19-72)	82.7±11.2 (58-100)	1.65±0.05 (1.54-1.75)	30.30±4.37 (20.07-38.14)
BaED	15	50.0	52.5±12.8 (32-83)	75.5±10.2 (48-94)	1.63±0.05 (1.5-1.71)	28.44±4.27 (19.47-37.78)
P-value			0.029*	0.011*	0.108	0.101

*Significant difference using Student-t-test for difference between two independent means at 0.05 levels

Table(2): Mean±S.D (Range) for kVp, mAs,Air kerma(mGy), Air kerma Rate (mGy/sec) and Fluoroscopy Time(min.)

Group	kVp	Q (mAs)	Air Kerma (mGy)	Air Kerma Rate (mGy/sec)	Fluoroscopy Time (minute)
BaMC	85.13±12.10 (70.0-120.0)	53.17±2.00 (50.0-56.0)	5.13±2.02 (1.45-8.64)	5.72±3.02 (1.74-11.59)	8.73±0.97 (1.49-15.0)
BaMD	73.83±6.07 (60.0-88.0)	56.73±3.86 (51.0-65.0)	4.74±2.14 (1.12-8.67)	4.02±1.78 (1.18-6.98)	7.67±0.45 (1.52-13.32)
P-value	0.0001*	0.0001*	0.478	0.010*	0.0001*
BaEC	88.67±11.03 (70.0-115.0)	61.33±6.17 (76.0-50.0)	4.78±2.4 (2.38-11,73)	2.68± 1.97 (1.05-9.67)	9.73±0.64 (3.52-15,0)
BaED	78.00±5.69 (70.0-88.0)	58.80±8.71 (45.0-75.0)	5.58±2.24 (1.10-9.78)	2.96 ±2.21 (1.05-9.75)	7.67±0.96 (1.52-13.32)
P-value	0.0001*	0.199	0.193	0.611	0.0001*

*Significant difference using Student-t-test for difference between two independent means at 0.05 levels.

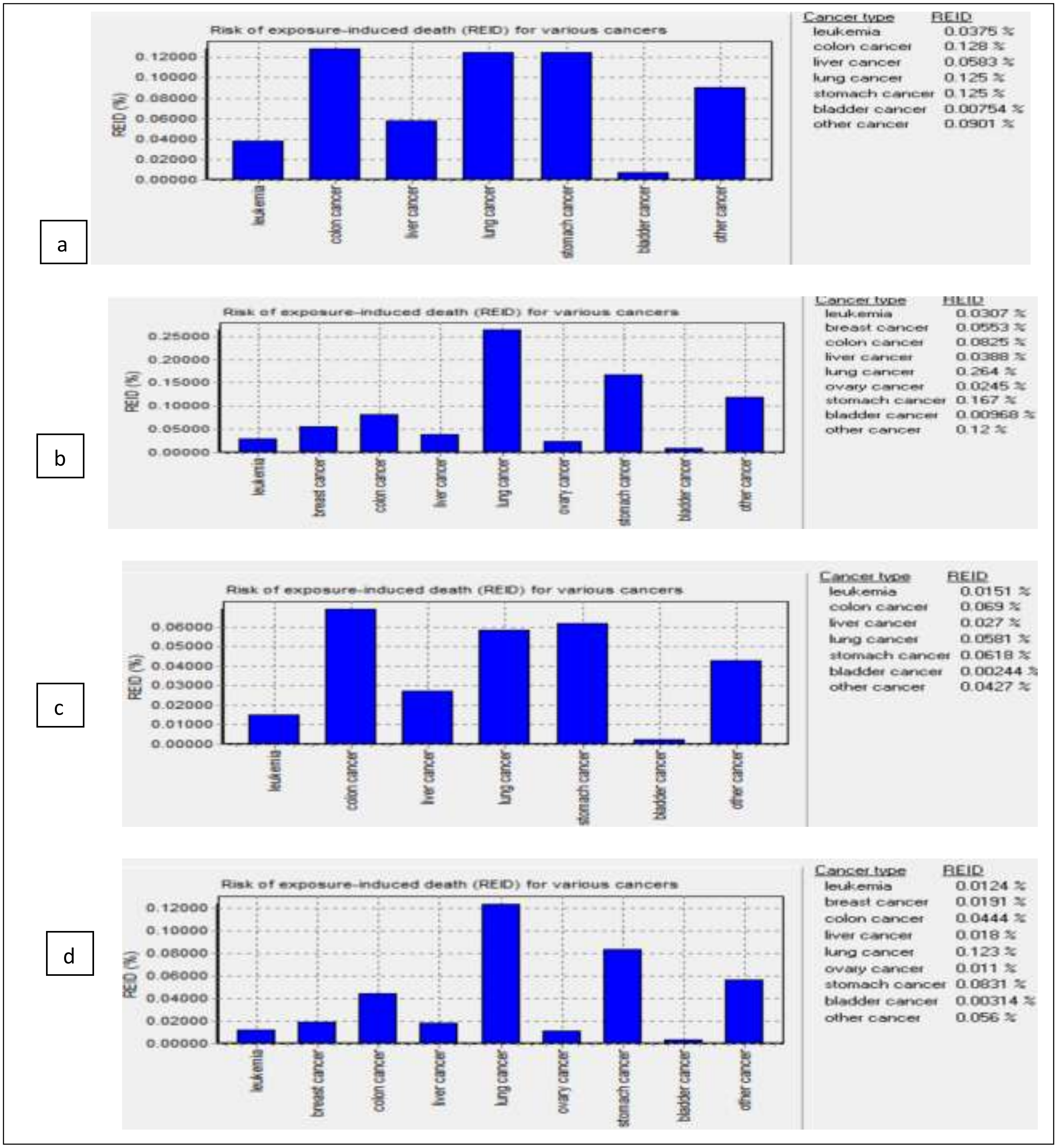
Table (3): Mean±S.D(Range) for Dose Area Product(Gy.cm2), Organs Dose (mGy) and Effective dose(mSv).

Groups	DAP (Gy.cm²)	Colon dose (mGy)	Liver (mGy)	Stomach Dose (mGy)	Effective dose (mSv) ICRP103	Effective dose (mSv) ICRP60
BaMC	25.20±2.41 (1.55-40.1)	7.75±3.04 (4.43-15.48)	12.34±4. (7.87-22.15)	18.54±6.1 (11.6633.29)	5.49±1.89 (3.33-10.38)	5.73±1.93 (3.47-10.96)
BaMD	12.80±0.68 (2.74-28.0)	4.15±1.74 (1.91-9.49)	5.70±2.40 (2.86-13.7)	9.17±3.86 (4.63-21.7)	2.72±1.22 (1.56-6.91)	2.62±1.16 (1.35-6.65)
value-P	0.0001*	0.061	0.348	0.140	0.001*	0.001*
BaEC	32.13±4.34 (25-40.0)	17.07±4.46 (10.67-29.81)	2.93±1.24 (1.10-7.27)	7.34±2.61 (2.87-16.18)	7.07±1.86 (4.65-12.6)	6.43±1.60 (3.93-10.92)
BaED	25.0±4.09 (20-33.0)	10.50±3.75 (23.81-5.85)	3.02±1.36 (8.47-1.22)	6.34±2.47 (15.97-2.98)	4.90±1.63 (2.97-10.87)	4.79±2.47 (9.42-1.47)
value-P	0.0001*	0.029*	0.529	0.719	0.095	0.095

*Significant difference using Student-t-test for difference between two independent means at 0.05 lev

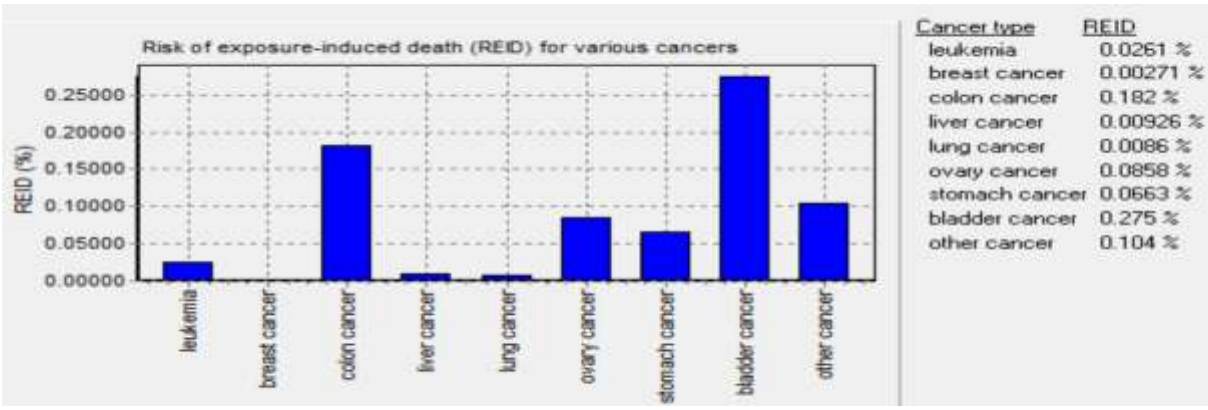
Table (4); the conversion factors (E/DAP) $mSv.mGy^{-1}.cm^{-2}$ for all examinations.

	BaMC	BaMD	BaEC	BaED
ICRP103	0.277	0.212	0.220	0.196
ICRP60	0.217	0.204	0.187	0.191



Figur(1) The reid % for BaM: **a.** for male patients in conventional fluoroscopy. **b**. for female patients in conventional fluoroscopy. **c.** for male patients in digital fluoroscopy. And, **d.** for female patients in digital fluoroscopy.

a.



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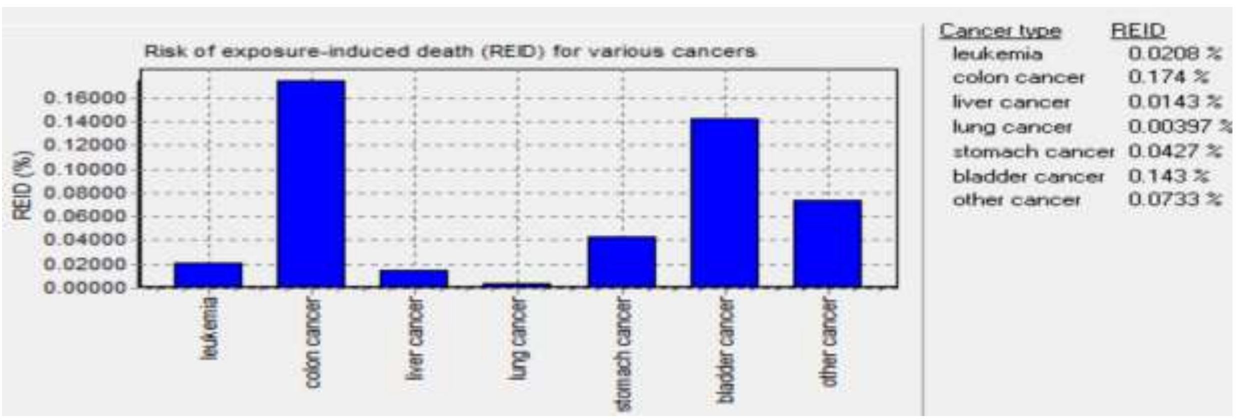

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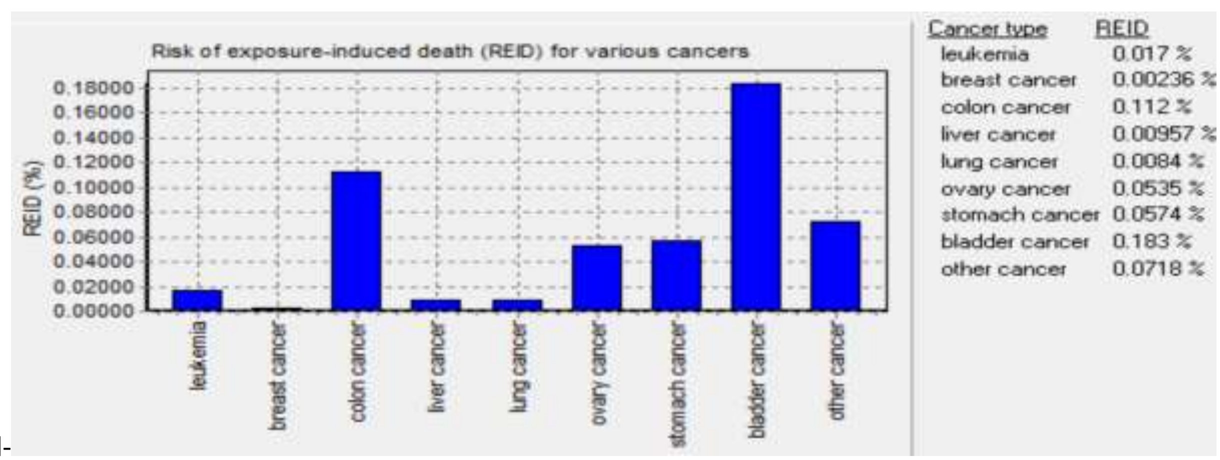

d-

Figure (2): The REID% for BaE: **a.** for male patients in conventional fluoroscopy. **b.** for female patients in conventional fluoroscopy. **c.** for male patients in digital fluoroscopy. And, **d.** for female patients in digital fluoroscopy.

Discussion:

These complex barium procedures are frequently requested. This research work describes methods of obtaining appropriate parameters for establishing patient dose and risk of exposure-induced death caused of cancer for barium procedures. Table (3) shows the variation of mean DAP values between digital and conventional systems for barium enema and barium meal examinations. And there are significant differences (p<0.001) between digital and conventional systems for both examinations. Also, both examinations have been included here to emphasize that the differences are dependent on the examination type. It can be seen that digital systems give a lower dose than non-digital systems for both examinations BaM and BaE. This result is agood agreement with those that obtained from similar study in University Hospital Birmingham, Birmingham, UK [10]. The mean±S.D for DAP values for a BaM investigation using a conventional system in the present study is 25.20±2.41 Gy.cm2 ; this compares with 12.80±0.68 Gy.cm2 for a digital unit, a reduction of nearly 50%. But, for a BaE investigation the reduction is much lower at 25%, where it is 32.13±0.25 Gy.cm2 for conventional system and 25.0±2.68 Gy.cm2 for digital unit. These results are a good agreement with that published from [10] for the BaM which reduced about 50% but for BaM is 15% is reduced the value is lower than that obtained in present study. Also, the DAP for BaE is higher than that recorded for BaM, this agood agreement with [11 and 12]. Also, for BM the reduction in screening time is approximately 13% (8.73–7.67min.) for digital units, compared with a reduction of 50% for DAP values. Thus, for BM, the variation in mean DAP values between the digital and conventional units cannot be attributed to the screening time alone. A reduction of 22% in screening times is seen for BE, compared with only a 25% reduction in DAP values. Not only the examination protocol or the geometrical and exposure conditions influence the calculated effective dose results but also the measured DAP value in each case is a crucial parameter. The coefficient factors (E/DAP) calculated by dividing the effective dose (mSv) by the DAP (Gy.cm 2), show table (4); note that the coefficient factors ranged between (0.187-0.277), this result compares with [12] where recorded the 0.17 and 0.24 for BaE and BaM, also with that recorded from NRPB which are estimated the coefficients for BaM and BaE to be 0.22 and 0.28 respectively[4] .The fluoroscopic exposure contributed approximately 85% of total DAP for all barium studies [12]. Differences in the coefficient factors can be due to the differences in the tube voltage, FSD and image size since organs may be in different positions with respect to the primary beam [13 and 4].According to Vehmas et al.(14), the factors controlled by the radiologists (Fluoroscopy time and number of radiographic exposures) accounted for 40% of the total variation in the effective dose; 16% of this variation is explained by patient-related factors and equipment-related factors account for the residual 44%. In another hand, the organ dose was estimated from this study, which is very difficult to estimate the organ dose in complex examinations according to Ruiz et al..[15]. The three organs that received higher dose in both examination and both system are the same, but changed according to the sequence of the highest dose taken where the first , second and third organ are (Stomach , Liver and Colon) for BaMC and BaMD , but the sequence are changed for BaEC and BaED,which are (Colon ,Stomach and Liver). The higher organ dose for BaM is Stomach (18.54±6.1mGy) for BaMC and (9.17±3.86mGy) for BaMD, this result is a good agreement with [7], which is recorded that the organs receiving the highest amounts of doses during BM examinations are the stomach. Finally, REID% was calculated for both examinations. The REID% values for female patients were slightly higher than the corresponding values for males for both examination groups, this results agreement with [8], this due to sensitivity of organs for radiation which are higher from female to the male patients. Also we note that the REID% values are higher from conventional procedure than that record for digital system may be due to the using high fluoroscopy time in conventional system.

Conclusion:

From this study concluded that digital systems give a lower dose-areaproduct than non-digital systems for both examinations BaM and BaE. Also, the DAP for BaE is higher than that recorded for BaM. The three organs that received higher dose in both examination and both system are the same, but changed according to the sequence of the highest dose taken where the first , second and third organ are (Stomach , Liver and Colon) for BaMC and BaMD , but the sequence are changed for BaEC and BaED,which are (Colon ,Stomach and Liver).Also, concluded that The REID% values for female patients were slightly higher than the corresponding values for males for both examination groups, and the REID% are higher from conventional procedure than that record for digital system.

The Aims of the Study

1. To analyses the factors behind the variation of patient doses during performing fluoroscopy examinations.

2. To evaluate the effectiveness and practicality of dose reduction measure and compare these values with international reference levels.
3. To compare the parameters related to patient dose in both digital and conventional system.

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