The effect voltage Device of x-ray on radiation doses and image quality

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Abstract
The X-ray tube generates diagnostic X-rays, and these rays can penetrate the human body and to different dimensions depending on the energy of the rays. These rays meet absorption and scattering inside the body, and whatever comes out of them is used for radiological examination purposes. Radiation exposure accompanies some of the potential risks, so it requires knowing the amount of radiation dose for the total exposed (man. Sv), as well as the equivalent effective dose for the organ or tissue in the body, and multiplied by the value determined by the risk factor, thus determining the amount of radiation risk or the rate of infection. Radiative damage. The surface entry dose values measured by the German-born Dosimax mobile device are closer to the reference values, because the sensitive size of this meter is a material equivalent to living tissue, which is exposed to X-rays, so the reading value of the dose in the air is not the same as in the case of the ionization chamber (Unfors) is Swedish in origin, but rather the dose of live tissue which is an approach to the dose of patients. The amount of fluctuation in the measuring voltages of the device (C) is 11.3% which is higher than the specified values, and also the standard deviation in the measurement is more than 5%, that is, the device does not meet the quality assurance specifications (QA), while the two devices (F, E) are The volatility value is 3.89% and 4.6%, respectively, which is less than the limits set for this fluctuation of 10%, and the standard deviation values are less than 5%.

Keywords: X-ray measuring device, Radiation dose, x-ray, quality assurance

INTRODUCTION
The black areas that appear after acidification of radial films are caused by silver metal. When X-rays fall directly, the energy of the photons is absorbed by one of the electrons according to the photoelectric phenomenon or the Combin phenomenon found in negative bromide ions to turn into a neutral bromide atom that leaves the crystal to be absorbed by the gelatinous material.

The small groupings of silver atoms form the centers of the latent image, which is one of the locations that are visible after the acidification process, in order to deposit the silver metal. The difference between the emulsion granules that interact with the acidification solution leads to the deposition of the silver metal between the grains that do not appear, leading to the formation of the latent image centers, and the final latent image consists of a large number of centers [4,7].
About (10 - 1)% of the energy of the falling photon is given by the electrons according to the photoelectric phenomenon, while the rest is prevented by gelatinous material. The sensitivity of the film to direct X-rays changes by (50 - 20) times with the energy of X-rays, as well as the method of acidification, and the white color (low light intensity) appears on the film in the event of attenuation in the radial beam, but if the beam is executed through the middle, the image appears as regions Black (high intensity optical) proportional to the amount of incident radiation [3]. After the discovery of X-rays, they were used directly in the field of treatment and medical diagnosis, and soon these early medical applications were accompanied by dangerous biological reflections and damages, the need to set and develop radiological protection criteria with the aim of monitoring X-ray uses in the medical fields by calibrating the devices and how to use and deal with them [5,6]. The principles that depend on prevention were that the received dose has certain limits that do not constitute visible effects throughout the life of the exposed individual and is called the Dose Tolerance, but there are genetic effects appearing on subsequent generations that were not taken into consideration, and on this principle the International Atomic Energy Agency issued Based on the recommendations of the International Committee for Radiation Protection (ICRP), the maximum permissible dose is set, so that the accumulated dose for a period of time or resulting from a single exposure does not constitute the possibility of any bodily harm (immediate effect) or genetic (delayed effect) depending on Available information, and in this period, various organizations took to develop protection standards for workers and harboring X-ray tubes inside shielding containers and reduced during periods of time the maximum allowed dose, due to the emergence of various disease states shown in Table (1).

Check of Voltage KVp

In this test, the difference in voltage between the two ends of the X-ray tube, which represents the anode voltage, is measured, because this voltage has an important relationship with the intensity of the X-ray coming from the tube and the degree of image clarity. The amount of voltage recorded on the control panel must be matched with the voltage measured by the devices; The intensity of the X-ray emitted from the device tube is proportional to the square of the peak voltage [50]. The voltages are measured using the digital scale directly, and the work of these devices depends on the use of two optical devices that convert the X-ray windows from two slices of copper of different thicknesses into a voltage difference that is proportional to the peak of the tube voltage after calibrating the device on such a measurement, and the device is usually placed at a distance of 100cm from The goal of the x-ray machine is exposed to x-rays, so the reading will be correct if the amount of change in voltage ranges between (10-25)%, and we need in the voltage test to two features:

1 - accuracy.
2- Evidence

MATERIAL AND METHODS

Instruments of Measurement Radiation Level

1-Dosimax

This device consists of a portable semiconductor type (solid state) detector [48] and is intended to detect relatively high-energy photons (X-rays). This detector is characterized by its small size, because the density of the semiconducting material, and it has a very fast response time and has The ability to change the thickness of the semiconducting material, to suit the required measurement conditions. It is also surrounded by a filter similar to the
tissues of the body, and in this photo diode detector, which has a great ability to sense X-rays, the detector is linked to a type (Dosimax) to give the dose rate, radiation dose, measurement time and voltage as shown in Figure 1.

Figure (1) represents an image of a device.

2- Unfors Instrument
This Swedish-made device consists of a detector that has an ionization chamber connected to a coated wire connected to a digital counter. The principle of this device's work is to collect electrons on the anode as a result of the fall of X-ray photons on the cathode.

The device is designed for quality assurance tests as it measures the dose, time, dose rate and voltage directly.

The most important features of this meter are its small size, accuracy in measurement, and the figure (2) shows a picture of the Unfors mobile device.

Figure (2) represents the image of the Unfors device.

3- RMI 240
The device is designed on the basis of differential absorption of X-rays through filters. This device uses four consecutive and parallel chambers to determine radiographic properties, which include kVp voltages, exposure time, linear current mA as well as dose and dose rate [51].

The device is of high sensitivity and special for quality assurance tests for X-rays as in Figure (3), and the work of this device depends on the use of bioluminescence that converts the window X-rays from two strips of copper of different thicknesses to a voltage difference that is proportional to the peak of the tube voltage, and after calibrating the device, it is placed under the target of the X-ray machine and exposed to it.
Quality Assurance

Quality Assurance Program: - It is a set of procedures related to the performance, equipment, and X-ray devices used in medical diagnostics. Quality assurance programs have been established and approved in the rules and laws of most countries in the world and in the safety standards of international organizations. The quality assurance program aims to: [49]

1 - Improving the image of the various textures of the body on the x-ray film or screen.
2 - Reducing radiation exposure to patients and workers.
3 - Reducing costs (film consumption, radiant tube life).

This program includes two main lines:
First: Automated tests
Second: - Radiological tests

RESULTS AND DISCUSSION

Features of X-Ray Instruments

Work was done on X-ray machines in the Specialized Surgeries Hospital in Medical City, and there are (3) devices. Table (1) shows the type of devices, the date of manufacture, and other information about X-ray devices.

Table (1) specifications of the X-ray machines that were worked on

| SID | mAs | Voltage kVp | Type of examination | The manufacturer and its history | hospital | NO |
|-----|-----|-------------|---------------------|-------------------------------|----------|----|
| 130 | 25  | 70          | AP Chest LAT        | SIEMENS 1995                  | Yarmouk  | A  |
|     | 35  | 85          |                     |                               |          |    |
| 85  | 30  | 80          | AP lembar spinal LAT| SIEMENS 2003                  | Yarmouk  | B  |
|     | 35  | 85          |                     |                               |          |    |
| 85  | 25  | 90          | AP abdomen          | SIEMENS 1980                  | Yarmouk  | C  |

There are many chest exams in this hospital, so ten patients were taken to examine the chest for each device and for each projection (projection) so that the error in measuring doses was the least possible, while the other tests took
at least five patients for each examination and took the average of these readings, the tests included adults from Gender, Table (1) shows the type of devices, date of manufacture and other information on

X-ray devices, for the purpose of measuring radiation doses in practice, TLD-100 thermal tablets were used that are small in size and do not interfere with patient examinations because they are transparent and can be attached to the patient’s body, as well as radiation dispersed from the patient’s body.

Voltage Test

For the purpose of the x-ray quality assurance test, devices of different origin and date of manufacture were chosen, which are three devices bearing the English letters (C, B, A).

To perform this test, we fix the current at a specified value by the control panel of the X-ray machine and the distance between the detector and the tube voltage is one meter and a time (0.1) seconds, and the radiation dose is measured for several values of the voltage, the device voltage is measured using portable and voltage devices installed on the control panel.

Tables (2), (3) and (4) show the radiation doses measured in the ionization rooms and the thermal flashing tablets, as well as the voltages of the mobile device and the voltage registered on the control panel.

Figures (4-1), (4-2) and (4-3) show the relationship between the radiation and voltage dose by fixing the current at the values (100, 200) mA for the following devices (C, B, A). which show that the device (E) is more stable than the other two devices because it is newly manufactured and under company maintenance.

The increase in voltages does not increase the radiation dose, but it leads to the interaction of incident radiation with the patient's body and consequently the increase in the dispersed rays. This is the reason that the relationships between radiation and voltage doses are non-linear.
Table 2 Radiation dose in milli-cay units for tube voltage values at current constant at values (100,200) mA by German and Swedish ionization chamber. For the X-ray machine the sequence C.

| X-ray voltage kVp | mA = 100 | ,Time = 0.1s | distance = 100 cm | Oscillation voltage % | Dosimax | Unfors | 240 RMI |
|-------------------|----------|--------------|-------------------|----------------------|---------|--------|---------|
|                   |          |              |                   | Dose mGy             |         |        | Dose mGy |         |         | Dose mGy |         |
| 40                | 43 ± 0.06| 6.98         | 2.47              | 2.68                 | 2.83    |
| 50                | 55 ± 0.07| 9.1          | 2.63              | 2.83                 | 2.96    |
| 60                | 66 ± 0.075| 9.0          | 2.78              | 2.89                 | 3.08    |
| 70                | 74 ± 0.08| 5.4          | 2.86              | 2.92                 | 3.19    |
| 80                | 87 ± 0.085| 8.1          | 2.94              | 3.04                 | 3.23    |
| 90                | 96 ± 0.09| 6.2          | 3.1               | 3.25                 | 3.35    |

| mA = 200 | ,Time = 0.1s | distance = 100 cm | Oscillation voltage % | Dosimax | Unfors | 240 RMI |
|----------|--------------|-------------------|----------------------|---------|--------|---------|
| 40       | 45 ± 0.06    | 11                | 2.61                 | 2.75    | 2.783  |
| 50       | ± 0.0761     | 18                | 2.73                 | 2.862   | 2.892  |
| 60       | 76 ± 0.08    | 21                | 2.88                 | 2.985   | 3.08   |
| 70       | 84 ± 0.085   | 16                | 2.97                 | 3.07    | 3.18   |
| 80       | 92 ± 0.085   | 13                | 3.12                 | 3.19    | 3.26   |
| 90       | 100 ± 0.09   | 10                | 3.19                 | 3.24    | 3.33   |

Mean 11.3
| X-ray voltage (kVp) | RMI 240 voltage (kVp) | Oscillation (voltg %) | Dosimax Dose (mGy) | Unfors Dose (mGy) | 240 RMI Dose (mGy) |
|--------------------|-----------------------|-----------------------|--------------------|-------------------|-------------------|
| 40                 | 43±0.008              | 6.9                   | 3.12               | 3.28              | 3.36              |
| 50                 | 52±0.01               | 5.6                   | 3.21               | 3.36              | 3.45              |
| 60                 | 62±0.02               | 3.2                   | 3.34               | 3.44              | 3.51              |
| 70                 | 72±0.03               | 2.7                   | 3.46               | 3.53              | 3.592             |
| 80                 | 83±0.035              | 3.6                   | 3.54               | 3.64              | 3.736             |
| 90                 | 93±0.04               | 3.2                   | 3.62               | 3.72              | 3.795             |

mA =200, Time = 0.1s, distance = 100 cm

|          |          |          |          |          |          |
|----------|----------|----------|----------|----------|----------|
| 40       | 41±0.007 | 3.6      | 3.31     | 3.552    | 3.583    |
| 50       | 52±0.01  | 3.8      | 3.43     | 3.596    | 3.67     |
| 60       | 62±0.02  | 3.2      | 3.53     | 3.655    | 3.76     |
| 70       | 73±0.03  | 4.1      | 3.65     | 3.773    | 3.84     |
| 80       | 83±0.035 | 3.6      | 3.67     | 3.78     | 3.91     |
| 90       | 93±0.04  | 3.2      | 3.75     | 3.81     | 4.01     |

mA =100, Time = 0.1s, distance = 100 cm

3.89 Mean

Table 3. Radiation dose in milli-cay units for tube voltage values at current constant at values (100,200) mA by German and Swedish ionization chamber For the X-ray machine the sequence E.
| X-ray voltage kVp | RMI 240 voltage kVp | Oscillation voltig % | Dosimax Dose mGy | Unfors Dose mGy | 240 RMI Dose mGy |
|------------------|---------------------|----------------------|-----------------|----------------|-----------------|
| 50               | 54±0.01             | 7.4                  | 1.85            | 2.13           | 2.17            |
| 60               | 62±0.02             | 3.2                  | 1.96            | 2.27           | 2.31            |
| 70               | 73±0.03             | 4.1                  | 2.18            | 2.361          | 2.438           |
| 80               | 82±0.035            | 3.0                  | 2.37            | 2.523          | 2.593           |
| 90               | 94±0.04             | 4.2                  | 2.43            | 2.61           | 2.64            |
| 100              | 103±0.045           | 2.9                  | 2.65            | 2.73           | 2.79            |

mA =200, Time = 0.1s, distance = 100 cm

| X-ray voltage kVp | RMI 240 voltage kVp | Oscillation voltig % | Dosimax Dose mGy | Unfors Dose mGy | 240 RMI Dose mGy |
|------------------|---------------------|----------------------|-----------------|----------------|-----------------|
| 50               | 55±0.01             | 9                    | 2.01            | 2.37           | 2.4             |
| 60               | 62±0.02             | 3.2                  | 2.17            | 2.46           | 2.52            |
| 70               | 75±0.03             | 6.6                  | 2.36            | 2.55           | 2.69            |
| 80               | 83±0.035            | 3.6                  | 2.581           | 2.771          | 2.86            |
| 90               | 46±0.04             | 6.2                  | 2.76            | 2.862          | 2.91            |
| 100              | 105±0.045           | 4.8                  | 2.83            | 2.91           | 3.01            |

4.6 Mean

Table 4: Radiation dose in milli-cay units for tube voltage values at current constant at values (100,200) mA by German and Swedish ionization chamber. For the X-ray machine the sequence F.
Table (5) represents surface entry dose measured by thermal flash disks and portable devices, and their comparison with the values of the International Atomic Energy Agency and the dispersion coefficient indication.

| Values IAEA | Factor Dispersion | Dose (mGy) | Type of examination | No |
|-------------|------------------|------------|---------------------|----|
|             |                  | Unfors)    | Dosimax             |    |
| 10          | 1.07             | 16.9 ± 1.45| 18.1 ± 1.2          | AB Abdomen |
| 30          | 1.07             | 45.4 ± 1.8 | 48.8 ± 1.3          | AP lembar spinal |
| 5           | 1.05             | 7.85 ± 1.2 | 8.2 ± 0.6           | AB LAT |
| 5           | 1.1              | 1.74 ± 0.17| 1.95 ± 0.2          | AB LAT |
| 1.5         | 1.07             | 0.67 ± 0.3 | 0.75 ± 0.2          | AP Chest |
| 5           | 1.07             | 6.5 ± 0.7  | 0.7 ± 0.5           | AP Chest |
| 30          | 1.08             | 39 ± 2.1   | 42.2 ± 1.2          | AP lembar spinal |
| 10          | 1.06             | 12.1 ± 1.2 | 1 ± 12.8            | AB Abdomen |
| 0.4         | 1.07             | 0.68 ± 0.3 | 0.73 ± 0.2          | AB Chest |
| 3           | 1.06             | 5.1 ± 0.5  | 5.4 ± 0.65          | LAT Head |
| 30          | 1.08             | 43 ± 1.2   | 46.3 ± 1.2          | AP lembar spinal |
| 10          | 1.08             | 13.5 ± 0.6 | 14.6 ± 0.63         | AB Abdomen |

Discussion
5-1 radiation doses resulting from diagnostic tests
In this study, many new devices with different origins were used, as mentioned above, the radiation dose was measured for several patients and for several parts of the body, and it is clear from the two tables that the values of the surface entry dose for the Spanish-origin X-ray apparatus with the symbol (E) are close to the international values approved, and that Because the device is newly imported and is still under maintenance by the company that tests its work performance periodically.

As for the measured dose values for the X-ray machine with the symbol (C), it is about twice the recommended dose globally, because the device is a quarter of a century old and did not undergo quality assurance tests previously, and these measurements show that the device is not fit for measurement, so the hospital administration uses it less frequently. The state of great momentum for patients.

The surface entry dose values for the X-ray machine with the symbol (F) are close to the reference values even though it is 10 years old, and this is due to the fact that it is a private sector device that maintains it well, in addition to the radiographer who is a retired person with experience in this field.

The surface entry dose values measured by the German-born Dosimax mobile device are closer to the reference values, because the sensitive size of this meter is a material equivalent to living tissue, which is exposed to X-rays, so the reading value of the dose in the air is not the same as in the case of the ionization chamber (Unfors) is Swedish in origin, but rather the dose of live tissue which is an approach to the dose of patients.
CONCLUSIONS

The average dose measured in this research for all devices in this study compared to the International Atomic Energy Agency (IAEA) reference dose, but it is generally greater than the reference doses with a range of (1.7 - 1.2) as in Table (5-2), although this increase does not pose a significant risk to patients, but it is preferable that the dose be less than that according to the ALARA law in radiation protection; Because the increase in the dose is not justified and this increase is due to the following:
1- Introduced some of the devices used in this study, and one of them has been used for 25 years continuously.
2- The large load to operate the device throughout working hours, due to the large number of patients and the small number of devices.
3- Most radiographers of these devices lack expertise and good training on these devices.
4- The absence of a program for quality assurance measurements for these devices in Iraq, and there is no great interest in the radiological risks of patients, and the only important thing is to obtain a good quality image that the radiologist can easily diagnose, as the radiographer uses a few kVp, and high exposure (mAs) is high so The image is good, the opposite should be done using high kVp and few (mAs) to make the dose small and the picture quality good.
5- Most of the films used in the measurement are of poor quality and require a long time to get a good picture.
6- Security and psychological conditions for the medical staff that negatively affect the quality of work.

Voltage Stability Test
A test of voltages is acceptable if the standard deviation in the measurement is less than ± 5% or if the fluctuation in its measured and recorded values is acceptable if the percentage of oscillation ranges between% (3-10) for devices with three phases and drives 12 pulses which are used in this research, The oscillation constant is measured from the following law [51]:

\[
\text{Oscillation voltage} \% = \frac{(kV_p)_\text{MIN} - (kV_p)_\text{MAX}}{(kV_p)_\text{MAX}} \times 100 \%
\]

Table (2) shows the amount of fluctuation in the measurement of the voltage of the device (C) is 11.3% which is higher than the specified values, and also the standard deviation in the measurement is more than 5%, that is, the device does not meet the quality assurance specifications (QA), either. The two devices (A, B) have an oscillation value of 3.89% and 4.6%, respectively, which is less than the limits set for this oscillation of 10%, and the standard deviation values are less than 5%.

Table (6) shows quality assurance tests for the three X-ray machines and their comparison with international values [51]:

| Values IAEA | Device(A) | Device(B) | Device(C) | Tests |
|-------------|-----------|-----------|-----------|-------|
| 10 %        | 4.6 %     | 3 %       | 11 %      | kV_p  |
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