Brief Report

Evaluation of Filtration Rates in Radiology Devices Used in Hospitals Affiliated to Babol University of Medical Sciences, Iran

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ABSTRACT

BACKGROUND AND OBJECTIVE: Filtration in radiology devices plays a pivotal role in weakening of soft X-ray photons and reduction of absorbed radiation dose by patients. This study aimed to evaluate the filtration rate of radiology devices at public hospitals affiliated to Babol University of Medical Sciences, Iran.

METHODS: In this cross-sectional study, we used the DIAVOLT device to measure the level of radiology filtration. DIAVOLT was placed under the X-ray tube and exposed to radiation by applying multiple potential differences to the radiology device. After radiation, output potential differences were measured and recorded.

FINDINGS: This study was performed at Ayatollah Rohani, Shahid Beheshti and Yahyanejad hospitals located in Mazandaran, Iran. Potential differences of 50-80 kilo-volts (kV) were applied to radiology devices, and output voltage of the DIAVOLT device was observed to be compatible with input potential at the standard error rate of ±5. In Amirkola Children's Hospital, level of filtration was 0.5 mm, while it was estimated at 2.5 aluminum mm in other hospitals. In addition, applied input time to the DIAVOLT device was compatible with output time. In Shahid Rajaee Hospital of Babolsar city, rate of input potential was higher than the output potential in the DIAVOLT device, which diverted from the standard level; however, filtration degree was adequate.

CONCLUSION: According to the results of this study, kV examinations were accurate at all the hospitals affiliated to Babol University of Medical Sciences. Therefore, it could be concluded that rate of filtration is adequate in the radiology devices used in these health centers.

KEY WORDS: Filtration, Diagnostic Imaging, Educational Hospitals, Babol University of Medical Sciences.

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Introduction

Protection against radiation exposure is of paramount importance in radiology since it mainly aims to reduce the radiation dose absorbed by patients and medical staff. Although use of X-rays yielded remarkable results during the early stages of invention, it gradually became clear that this type of radiation could lead to different problems, such as cutaneous disorders. X-rays that are produced from a thick target without any filters in the front normally contain different levels of photon energy (zero-maximum), as well as variable penetration degrees.

When the patient is exposed to an X-ray beam, most of the low-energy photons are absorbed by body's surface, and only a few might penetrate deeper or exit from the other side of the body. This spectrum of X-ray beams does not influence image formation; however, it might have devastating effects on the patient, leading to increased absorption of radiation dose and several complications. For instance, unnecessary absorption of radiation beams heightens the risk of different cancers. Therefore, this part of X-ray beams should be removed before colliding with the body, and filtrations are considered as practical options in this regard (1-4).

Rate of X-ray filtration is determined based on the kilo-voltage (kV) used to generate the beams. Thickness of the filtering material depends on different parameters, such as the atomic number, kV setting and other factors associated with ideal filtration. Filters are usually in the form of metal plates, which are placed between the patient and X-ray tube. Absorbent materials are used to filter X-ray beams in two stages, starting from the radiation source. The device for this process consists of a shielded X-ray tube for inherent filtration, and metal plates inserted along the pathway of X-ray beams for additional filtration (5).

Inherent filtration is usually equivalent to 0.5-1 aluminum mm since at thickness of 2 mm, aluminum is able to absorb all photons with energy level of <20 kilo-electron volts, and maximum output is also achieved at this degree of thickness (6-10).

In this study, accuracy of potential differences in radiology devices was evaluated through parameters such as kV accuracy, in order to determine the compatibility between the adjusted kV input on X-ray machine control panel with the energy level of X-ray beams (i.e., kV output), considering a standard error rate of ±0.5% (11).

Differences above the standard level could be caused by factors such as voltage fluctuations in power systems, faulty high-voltage transmission cables and presence of bugs in the auto-transformator circuit (12). This study aimed to evaluate the filtration rate and accuracy of potential differences in radiology devices used in public hospitals affiliated to Babol University of Medical Sciences, Iran.

Methods

This cross-sectional study was conducted on the radiology devices of five public hospitals (Shahid Beheshti, Shahid Rajaee, Ayatollah Rohani, Shahid Yahyanejad and Amirkola Children's Hospital) to assess the accuracy and precision of kV peak, accuracy of time and rate of radiation absorption dose at different exposures. Among the selected health care centers, radiology devices used at Shahid Beheshti, Ayatollah Rohani, Shahid Yahyanejad and Amirkola Children's Hospital were approved in terms of the studied variables. In imaging tests, we used a DIAVOLT device (Model T43014-01344, PTW, Germany) for the measurement of kV output, output time and filtration level. Moreover, DIADOS Diagnostic Dosemeter (Model T11035-00495, PTW, Germany) was used to determine radiation dose.

In addition to inherent filtration, radiology devices have additional filtration in the form of aluminum sheets, with the thickness regulated in millimeters. In the present study, rates of inherent filtration (on the back of each tube) and additional filtration (manually placed inside the tube) were measured and recorded. Total filtration level of radiology devices was calculated by summing up the additional and inherent filtration rates, and the result was applied in the DIAVOLT device. It is noteworthy that these values were variable between the studied hospitals.

Size of radiation field was set at 6×6 cm in all examinations, based on the initial calibration of the measurement system. Afterwards, film-focus distance (i.e., distance between the source of X-ray beams and DIAVOLT or cassette) was considered to be 100 cm.

To start the examinations, several kV potential differences at milliampere (mA) of 200 and time of 0.3 were applied to radiology devices. Radiology time of 0.3 is frequently employed in radiographic techniques. Initially, the radiology device was set at voltage of 50 kV, and radiology output was read using the DIAVOLT device. Following that, radiation dose and exposure time were displayed in this device and recorded in tables.

Moreover, another examination was performed under similar conditions (voltage: 50 kV, mA: 200, time: 0.3), and obtained data were read and recorded from the DIAVOLT device.

Repeated tests at the voltage of 50 kV were conducted in order to control kilo-voltage peak (kVp) constantly at different exposures. In the next stage, kVp was set at 60 in the radiology device, and kVp output, output time and radiation dose were recorded from the DIAVOLT device. This process was repeated at kVp of 70 and 80, and differences in outputs were recorded in tables.

Result

Based on the observed potential differences of voltage, factors such as mA, time used per device, voltage rate, output time and radiation dose were measured and recorded, as follows:

Yahyanejad Hospital: In this hospital, voltage of 50-80 kV with mA of 200 and time of 0.3 were applied on the radiology device. Mean of kV and output time was estimated at 67.28 and 0.24, respectively, while mean of radiation dose was calculated at 189.98 µGy.

Shahid Rajaee Hospital: With voltage of 50-80 kV, mA of 200 and time of 0.3, mean of kV and output time was estimated at 87.93 and 0.3, respectively, while mean of radiation dose was calculated at 1181 µGy.

Amirkola Children's Hospital: At voltage of 40-62 kV, mA of 200 and time of 0.3 applied to the radiology device, mean of kV and output time was estimated at 51 and 0.296, respectively, while mean of radiation dose was calculated at 8495 µGy.

Shahid Beheshti Hospital: In this hospital, with applied voltage of 50-80 kV, mA of 200 and time of 0.3 to the radiology device, mean of kV and output time was estimated at 67.11 and 0.3, respectively, while mean of radiation dose was calculated at 306.42 µGy.

Rohani Hospital: With applied voltage of 40-70 kV, mA of 200 and time of 0.32, mean of kV and output time was estimated at 58.93 and 0.32, respectively, while mean of radiation dose was calculated at 139.95 µGy. Mean values for kV output, output time and radiation dose are presented in table 1.

Table 1. Mean of KV Output, Output Time and Radiation Dose

Hospital	kV Output Mean±SD	Output Time (Second) Mean±SD	Radiation Dose
Shahid Yahyanejad	67.28±1.21	0.24±0.01	189.89±2.29
Shahid Rajaee	87.93±2.51	0.30±0.03	1189±7.9
Amirkola Children's Hospital	51±1.5	0.29±0.03	849.5±7.55
Shahid Beheshti	67.11±2.11	0.30±0.02	306.42±4.33
Ayatollah Rohani	58.93±0.99	0.32±0.01	139.95±4.29

*mA=200 in all Hospitals, Additional Filtration=2.5 Aluminum mm (Amirkola Children's Hospital: 0.5 mm)

Discussion

According to the obtained results of this study, level of aluminum additional filtration in the radiology devices used at Shahid Beheshti, Shahid Yahyanejad and Ayatollah Rohani hospitals was 2.5 mm, which is compatible with the standard rate (7). Furthermore, degree of additional filtration was calculated to be 0.5 in Amirkola Children's Hospital, which is correspondent with the standard rate in a specialized medical center for children (7). On the other hand, differences between input and output kV were observed to be above the standard rate, which could be due to voltage fluctuations in the power systems of hospitals, as well as possible faults in voltage transmission cables. These cases were reported directly to related authorities at the studied hospitals.

In conclusion, given the significant effects of filtration degree on the absorbed radiation dose by patients and medical professionals, it is recommended that regular investigations be conducted within 5-year intervals in this regard.

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