Polish Journal of Medical Physics and Engineering 2018;24(1):37-41 March 2018
doi: 10.2478/pjmpe-2018-0006
ISSN 1898-0309

Technical Note

Comparison of incident air kerma (k_i) of common digital and analog radiology procedures in Kohgiluyeh and Boyer-Ahmad province

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(received 29 July 2017; revised: 4 November 2017, 16 December 2017, 15 January 2018; accepted 13 February 2018)

Abstract

Introduction: Although in many developed countries, Analog radiography (AR) is replaced with digital radiography (DR) but AR is still widely used in many countries included Iran. Therefore, dosimetrically assessment of delivered dose is very important to avoid unnecessary patient dose.

Materials and Methods: In this study, all imaging centers in Kohgiluyeh and Boyer-Ahmad were selected. The initial information included the mean kVp and mAs used by the personnel to perform each radiological procedure were gathered through a questionnaire. Barracuda dosimeter was then used to measure Incident air kerma (k_i). Data obtained from digital radiography (DR) and analogue radiography (AR) were then analyzed and compared to each other.

Results: The mean incident air kerma (k_i) for five radiological procedures (chest AP&Lat, Skull AP&Lat, Lumbar spine AP&Lat, Thoracic spine AP&Lat and Pelvis) in digital devices were 0.38&1.34, 2.1&1.94, 4.99&7.83, 4.18& 6.41 and 4.33 mGy and those for analogue devices were 0.7&1.28, 3.05&3.02, 7.25&9.9, 7.125&8.36 and 5.36 mGy, respectively.

Discussion and Conclusion: The use of low kVp or high mAs is one of the reasons to increase the incident air kerma (k_i) in analogue methods comparing to digital methods in all procedures except the chest (in Lateral view). Also the results, surprisingly, showed that in some of the analogue methods incident air kerma (k_i) was less than digital methods which is most probably because of the auto-exposure conditions.

Introduction

Despite the advent of new imaging methods such as MRI, ultrasound and CT scan, conventional radiography is still one of the most widely used and useful methods in medical imaging. In the last half century, there have been many changes in medical imaging, which is evidence of the transition from analog to digital imaging [1,2]. Digital radiography is one of the most advanced medical imaging technologies in the last decade. In many developed countries, radiographic films have been removed from the X-ray imaging system [3,4]. The speed of development of digital radiography (DR) and computerized radiography (CR) have been as fast as the speed of cross-sectional imaging techniques such as MRI and CT. In comparison with the film-screen system, modern CR and DR systems are more effective to reduce the patient kermas and therapeutic expenses. However, based on recent researches, reverse effects can also occur, which can lead to increase patient kerma or missing diagnostic information due to the inappropriate use of digital devices software or the inability of radiographers to apply different radiology techniques, and, consequently, to reduce the quality of images resulting from processing Improper image quality or inappropriate image display [5-8]. There is no film blackout at high doses in the digital system, but the danger of Dose Creep, meaning the increase of patient's exposure during the manual setting of the tube in the digital system needs to be considered. Since the use of ionizing radiations has been associated with probable risk of cancer, Therefore, with increasing awareness of radiation protection, the concept of "the quality of image must be as well as possible" must be replaced with "the quality of image must be as well as it is needed" [6,9-11].

Considering to this fact that the dose of patients in digital radiography depends on several factors, it cannot be conclusively stated that digital radiography necessarily reduces patient dose [12-14]. Therefore, this study seeks to find out if in all digital radiology centers of the province, the patient dose is less than common radiography.

Materials and Methods

Experimental area: Kohgiluyeh and Boyer-Ahmad is one of the provinces of Iran. The center of this province is city of Yasuj, with an area of about 17,000 square kilometers and a population of seven hundred thousand people in the southwest of Iran. In the period of September to March 2017, 25 analog and digital units, included all public and private imaging centers in Kohgiluyeh and Boyer-Ahmad province, were investigated to calculate the incident air kerma (k_i) for five common radiology procedures (Skull AP/Lat, Chest AP/Lat, Lumbar AP/Lat, Thoracic AP/Lat and Pelvic AP). In each center, the radiation conditions were obtained by the questionnaire containing radiation information (kVp, mAs, and FFD) for all imaging devices in all work hours. In order to reduce the effect of scattered beams on the results, the field size was set to the size of dosimeter. To measure the incident air kerma (k_i), the Barracuda solid dosimeter of the RTI model was calibrated before the start of measurements at the SSDL Lab of the Atomic Energy Organization. The measurements were performed by placing the detector under the radiological tube at a mean distance applied by the personnel to each organ, and the average applied exposure by personnel to each organ was applied to the detector. In each measurement, kVp, mAs and the entrance kerma were recorded. It should be mentioned that for all measurements, the primary filter was set to 2.5 mm Al. Due to the effect of the distance of X-ray tube to the surface of the skin on the delivered kerma, to achieve an actual distance from the surface of the tube to the surface of the skin (FSD), the thickness of the targeted organ (Skull, Chest, Lumbar, Thoracic, and Pelvic) was reduced from the distance determined by personnel. This method is validated in a similar study [15,16]. The measurements in both types of digital and analogue devices were repeated three times and the average of measured values was recorded as incident air kerma (k_i) of the targeted organ. Then the incident air kerma (k_i) for various radiological procedures based on their type (digital or analogue) and their location (private or public center) were compared. The results were also compared with the NRPB standard data [17].

Results

Table 1 shows the comparison of the average kVp, mAs and FFD between analogue and digital procedures. **Table 2** shows the comparison of incident air kerma (k_i) between analogue and digital devices with standard values of NRPB. **Table 3** shows incident air kerma (k_i) values of five radiological procedures (Pelvic, Thoracic, Lumbar, Skull and Chest) for all 25 private and public centers.

Discussion

Table 1 shows the average conditions of kVp and mAs applied in the digital radiography of chest (PA) were 63 and 23, respectively, and those for the analogue radiography of chest were obtained to be 60 and 28, respectively. It means that in digital imaging procedures, high kVp together with low mAs has been used to keep the constant image density. This proportion for other procedures was also observed. According to the law of fifteen percent [18,19], it is possible to reduce the amount of mAs to its half by increasing kVp up to its 15 percent without any change in image density.

Table 1 also indicates that low potential technique is applied in all of the analogue procedures, resulting in higher mAs. Considering to this fact that the differences in FFD values for AR and DR settings were not significant (**Table 1**), it can be concluded that higher mAs for AR imaging techniques will always lead to higher patient dose.

In all measurements (**Table 2**), except for the chest (Lateral view), the amount of incident air kerma (k_i) in digital imaging devices is less than that of analogue devices. The conditions used by the radiation staff are one of the reasons of this difference. Despite the average increase in the amount of incident air kerma (k_i) in analogue devices comparing to digital devices, the incident air kerma values of digital devices had a high average radiation dose comparing to the standard values of NRPB. It could be because of inappropriate design of digital software applications.

Table 3 surprisingly shows, in some of the analogue devices in the current study, dose reduction was observed comparing to digital methods. For instance, for skull, it was showed that incident air kerma (k_i) is much lower (2 mGy) than the obtained incident air kerma (k_i) in the digital device number N (3.3 mGy). In a few digital devices, this increase was observed. One of the reasons of this increase is auto-exposure which means the radiation operator did not apply any changes in the conditions of the radiation (kVp, mAs and FFD) and for different people of different dimensions, the same conditions were applied [20].

In addition to technical factors investigated in this study, the previous studies show that the geometric parameters such as field size, the type of intensifier of cassettes (in analogue devices) and the speed of film should also be considered [21-24]. Furthermore, the weight and physical parameters, the technical knowledge of staff, and the type of film processor (in analog devices) are also shown to be important as well [25,26].

Higher incident air kerma (k_i) obtained in current study comparing to the values reported by British National Radiation Protection Board (NRPB) [10], as a credible reference shows that the application of radiation conditions in all of the province's facilities needs to be essentially revised.

Table 1. The comparison of kVp, mAs and FFD between analogue and digital devices.

Examination	FFD (cm)		mAs (Mean ± SD)		kVp (Mean ± SD)	
	AR	DR	AR	DR	AR	DR
Chest PA	150 ± 6.2	156 ± 7.2	28.2 ± 5.5	23.47 ± 6.7	60.2 ± 7.5	63.8 ± 9.05
Chest Lat	148 ± 8.3	147 ± 9	32 ± 6.3	28.5 ± 3.87	70.9 ± 7.3	73.9 ± 7.4
Skull AP	75 ± 4.1	80 ± 3.2	26.3 ± 3.6	21.7 ± 2.8	62.1 ± 3.2	63 ± 3.5
SKULL Lat	75 ± 4.1	80 ± 3.2	25.2 ± 3.4	20.36 ± 2.3	59 ± 4.1	60.7 ± 5.1
Lumbar AP	76 ± 4.3	76 ± 6.1	27.3 ± 6.7	25.3 ± 2.4	75.2 ± 9.2	76.13 ± 9.6
Lumbar Lat	77 ± 2.1	77 ± 3	45.9 ± 6.3	40.2 ± 5.5	77.3 ± 6.5	78.9 ± 7.5
Thoracic AP	74 ± 5.1	75 ± 3.3	28.1 ± 3.5	24/7 ± 2.6	66.9 ± 4.9	72.4 ± 7.9
Thoracic Lat	77 ± 2	78 ± 2.1	40.1 ± 6.6	36.6 ± 5.2	65.2 ± 7.3	77 ± 7.2
Pelvic	72 ± 3.3	73 ± 2.2	26.1v3.6	22.41 ± 2.4	63.25 ± 5.6	70 ± 6.3

Table 2. The Comparison of incident air kerma (k_i) between analogue and digital devices

Study	Mean ± SD DR (mGy)	Mean ± SD AR (mGy)	Mean AR&DR (mGy)	Mean (AR&DR) NRPB (2010) (mGy) [10,17]
Chest PA	0.38 ± 0.13	0.7 ± 0.25	0.49	0.16
Chest Lat	1.34 ± 0.51	1.28 ± 0.47	1.32	0.48
Skull AP	2.1 ± 0.59	3.05 ± 1.02	2.41	1.8
SKULL Lat	1.94 ± 0.59	3.02 ± 1.02	2.28	1.1
Lumbar AP	4.99 ± 1.43	7.25 ± 0.7	5.71	4.6
Lumbar Lat	7.83 ± 1.9	9.9 ± 1.28	8.49	7.9
Thoracic AP	4.18 ± 1.16	7.125 ± 0.85	5.12	2.9
Thoracic Lat	6.41 ± 1.5	8.36 ± 0.98	7.03	5.2
Pelvic	4.33 ± 1.14	5.36 ± 0.99	4.66	3.2

Table 3. The incident air kerma (k_i) of five radiological procedures (Pelvic, Thoracic, Lumbar, Skull and Chest) for all 25 private and public centers

Center	Device	Study and projection								
		Pelvic (mGy)	Thoracic (mGy)		Lumbar (mGy)		Skull (mGy)		Chest (mGy)	
		AP	Lat	AP	Lat	AP	Lat	AP	Lat	PA
A		3	5.3	4.16	5.65	5	1.1	1.1	1	0.36
B		5.3	7.1	5.6	7.9	6.98	2.1	2.3	0.8	0.51
C		5.3	7	5.9	7	6.2	1.9	2	1.5	0.53
D		4.9	7.71	4.95	7.78	6.74	2	2.1	2	0.3
E		4	5.1	3.1	6.8	5.3	1.5	1.5	1.7	0.41
F		3.01	5.64	3.74	5.64	3.74	2.75	2.35	0.8	0.71
G		2.03	3.78	2.87	4.07	3.8	2	2.1	1.60	0.24
H		2.84	4.55	2.39	9.03	3.41	1.57	1.44	2.1	0.36
I	DR	3.01	5.5	3.37	8.13	4.02	2	3.1	1.9	0.29
J		5.03	6.23	3.02	7.03	3.44	2.57	2.85	1.3	0.45
K		5.3	9.4	4.5	10	6	2.2	2.4	1.1	0.3
L		5.3	8.7	5.3	12	6.4	1.5	2.1	1.2	0.6
M		5.8	8.15	6.3	10.1	6.41	2.1	2.11	2.3	0.3
N		4.31	7	4.25	9	7.01	3.3	3.2	0.8	0.25
O		4.3	5.15	3.16	6.69	3.33	2.2	2.2	1.12	0.4
P		5	6.2	3.6	7.7	3.6	1	1.3	0.9	0.3
Q		5.3	6.5	5	8.7	3.6	1.21	1.7	0.7	0.3
R		6	8.9	7.1	11.1	8	3.9	4	2	0.76
S		5.5	8.6	6.9	10.5	7.8	3	3.1	1.5	0.8
T		3.4	7.8	6	9	6	2.9	2.9	0.9	0.4
U	AR	4.5	8.01	5.9	8.2	7.2	2.5	2.5	1	0.8
V		6.1	9.1	7.8	9.9	7.5	4.3	4.3	1.3	0.9
W		6.2	10	8.1	12.1	8.1	4.1	4.1	1.9	1.1
X		5.1	7.6	8.1	8.9	6.9	2	2	0.9	0.4
Y		6.1	6.9	7.1	9.5	6.5	1.5	1.5	0.8	0.5

Conclusion

The current study showed that radiation conditions (kVp and mAs) are important factors to determine the Incident air kerma (k_i) of digital and analogue radiography procedures. Applying high kVp together with reducing mAs and increasing FFD are the one of the best methods to reduce incident air kerma (k_i). It is also concluded that in the province of Kohgiluyeh and Boyer-Ahmad, for most of the radiology centers, incident air kerma (k_i) for both digital and analogue procedures is more than the standard values. Furthermore, the results, surprisingly, showed that in some of the analogue methods, incident air kerma (k_i) was less than digital methods which is most probably because of the auto-exposure conditions.

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