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Assessing Radiographic Technologist Precision and its Influence on Patient Exposure Index: Analytical Retrospective Study in a Small Palestinian Government Hospital

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Abstract:

This observational retrospective study conducted at Hussein Governmental Hospital in Bethlehem, Palestine, aimed to compare internationally recommended exposure levels with the actual exposure settings employed by radiation technologists. Inclusive of both genders and diverse age groups, the study utilized Toshiba flat panel detectors and closely observed exposures across various radiographic image types. Data analysis, performed using SPSS, included a one-sample t-test, ANOVA, and Pearson correlation. The results revealed that, on average, the current Exposure Index (EXI) did not significantly differ from the recommended standards, indicating the proficiency of technologists. However, deviations were observed in Kilovoltage Peak (kVp) settings, emphasizing the need for technologists to interpret automatic exposure controls accurately. The study found no significant differences in EXI related to image type, gender, or age, affirming the logical correlation between parameters and distinct exposure indices. Notably, a significant relationship was observed between acceptance by technologists and the Deviation Index, suggesting challenges in visually distinguishing accepted and rejected images. This study assesses radiation technologists' adherence to international exposure standards using Toshiba detectors. While overall compliance is observed, deviations in Kilovoltage Peak settings indicate a need for improved control interpretation. The findings contribute to optimizing radiation exposure and image quality in clinical radiography, particularly in resource-constrained settings.

Keywords: *Exposure Index; Conventional X-Ray; Kilovoltage Peak; Exposure Deviation Index.*

تقييم دقة فني التصوير الشعاعي وتأثيره على مؤشر تعرض المريض: دراسة تحليلية استرجاعية في مستشفى حكومي فلسطيني صغير

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ملخص:

تهدف هذه الدراسة التي أجريت في مستشفى الحسين الحكومي في بيت لحم/ فلسطين إلى مقارنة مستويات التعرض الموصى بها دوليًا مع إعدادات التعرض الفعلية التي يستخدمها تقنيو الإشعاع. وشملت الدراسة كلا الجنسين والفئات العمرية المتنوعة، واستخدمت أجهزة الكشف المسطحة من توشيبا ورصدت التعرضات عن كثب عبر أنواع مختلفة من الصور الشعاعية. شمل تحليل البيانات، الذي تم إجراؤه باستخدام برنامج SPSS، اختبار t لعينة واحدة، وANOVA، وارتباط بيرسون. وكشفت النتائج أن مؤشر التعرض الحالي (EXI) لم يختلف بشكل كبير عن المعايير الموصى بها، مما يشير إلى كفاءة التقنيين. ومع ذلك، فقد لوحظت انحرافات في إعدادات ذروة الجهد الكيلو فولتي (KVp)، مما يؤكد الحاجة إلى قيام التقنيين بتفسير عناصر التحكم التلقائية في التعرض بدقة. لم تجد الدراسة أي فروق ذات دلالة إحصائية في EXI تتعلق بنوع الصورة أو الجنس أو العمر، مما يؤكد الارتباط المنطقي بين المعلمات ومؤشرات التعرض المتميزة. ومن الجدير بالذكر أنه لوحظ وجود علاقة كبيرة بين القبول من قبل التقنيين ومؤشر الانحراف، مما يشير إلى تحديات في التمييز بصريًا بين الصور المقبولة والمرفوضة. تقوم هذه الدراسة بتقييم مدى التزام تقنيي الإشعاع بمعايير التعرض الدولية باستخدام أجهزة كشف توشيبا. لملاحظة الامتثال العام، إذ تشير الانحرافات في إعدادات ذروة الجهد الكيلو إلى الحاجة إلى تحسين تفسير التحكم. كما تسهم النتائج في تحسين التعرض للإشعاع وجودة الصورة في التصوير الشعاعي السريري، وخاصة في البيئات المحدودة الموارد.

الكلمات المفتاحية: *مؤشر التعرض؛ الأشعة السينية التقليدية؛ ذروة كيلوفولتية؛ مؤشر انحراف التعرض.*

1. Introduction

The exposure index serves as a feedback method for digital radiography technologists, offering an estimate of exposure on the detector and indirectly indicating digital image quality. However, the multitude of index values and methods among manufacturers complicates data sharing in environments with diverse vendors (Makhamrah et al., 2019; Ahmad et al., 2020; Al-Tell et al., 2019; Makhamrah et al., 2019; Ban et al., 2021; Muntaser et al., 2019; Ahmad et al., 2020; Ahmad et al., 2022; Hjouj et al., 2022; Oglat et al., 2022; Kmail et al., 2022, Ahmad et al., 2022).

A new exposure index, established as an international standard by the International Electrotechnical Commission and the American Association of Physicists in Medicine, aims to address this issue. While it doesn't signify patient dose, adopting the standardized exposure index is expected to enhance technologist performance, promoting uniformity and optimized radiographic techniques for safer pediatric care (Makhamrah et al., 2019; Ahmad et al., 2020; Makhamrah et al., 2019; Ban et al., 2021; Ahmad et al., 2022, Ahmad et al., 2022; Seibert et al., 2011; Ahmad et al., 2021; Ahmad et al., 2021, S. Ahmad et al., 2020; Ahmad et al., 2022, Ahmad et al., 2022)

Standardized terminology will benefit radiologists, and the development of a national dose index registry database will facilitate comparisons among institutions and clinics. The Alliance for Radiation Safety in Pediatric Imaging plays a crucial role in supporting and advocating for pediatric patients in this context (Ahmad et al., 2020; Makhamrah et al., 2019; Ban et al., 2021; Ahmad, et al., 2019; Ahmad et al., 2020; S. Ahmad et al., 2022; Seeram et al., 2014; Nassef et al., 2020; Mohammad et al., 2020).

Abnormal variations in radiation doses received by patients significantly impact image quality, anatomical clarity, and the radiologist's commitment to precise exposure doses for imaging. Standardizing the required radiation dose for each image and organ is essential for radiologists. The current study addresses the challenge of assessing radiologic technologists' ability to set specific x-ray parameters (kVp, mAs) to produce acceptable and diagnosable images with the correct exposure index, ensuring both image quality and patient safety (Makhamrah et al., 2019; Ban et al., 2021; Ahmad et al., 2022; Suliman, 2020; S.Ahmad et al., 2020; Muntaser et al., 2018)

The research objectives encompass different key aspects. Firstly, the study aims to compare the exposures recommended by the manufacturing company with those employed by technologists at Hussein Hospital- Bethlehem, Palestine, using Bontrager book as a reference for these doses. Secondly, the focus is on determining optimal x-ray doses for radiation imaging workers to enhance image clarity and facilitate accurate diagnoses by radiologic technologists. This involves distinguishing between excessive exposure and underexposure in radiography.

By achieving these objectives, the research seeks to contribute valuable insights into improving the precision of radiographic techniques, ensuring optimal imaging parameters, and ultimately enhancing patient care through reduced radiation exposure and enhanced diagnostic accuracy.

Materials and Methodology

The current research utilized an observational retrospective approach to compare the internationally recommended exposure levels with the actual exposure settings employed by radiation technologists at Hussein Hospital. The study was conducted at Hussein Governmental Hospital, located in Bethlehem, in the West Bank region of Palestine. This hospital served as the primary setting for the observational retrospective analysis, providing valuable insights into the practices of radiation technologists in a specific healthcare context. In terms of inclusion criteria, the study encompassed both male and female patients undergoing plain X-ray examinations. Notably, there were no age restrictions imposed, making the research inclusive of a diverse patient population. However, certain exclusion criteria were applied, including the exclusion of X-ray exams conducted in years other than 2021, patients with prostheses in their bodies, and portable studies conducted outside the designated department. These criteria aimed to ensure the relevance and specificity of the data collected for the study's objectives.

All X-ray examinations in this study utilized Toshiba flat panel detectors from the DIDA product package, which includes thin-film transistor (TFT) flat panel X-ray detectors. The exposures applied by technologists were closely observed and subsequently compared to the recommended kVp and mAs outlined in Bontrager's textbook of positioning. This analysis aimed to evaluate the alignment between the actual doses administered and the internationally recommended standards, providing insights into the practices of technologists in relation to established guidelines.

Table 1: parameter factors recommended by Toshiba manufacturer

Examination	Projection	kVp	mAS	Source to skin distance (SSD) (cm)	Radiation filed size (cm^2)
Abdomen	AP	64-70	50-60	75	33×40
	PA	64-70	50-60	75	33×40
Lumbar spine	AP	64-70	50-60	75	20×40
	PA	64-70	50-60	75	20×40
	RLAT	78-88	60-80	55	14×18
	LLAT	78-88	60-80	55	14×18
	RPO	72-80	54-70	70	21×28
	LAO	72-80	54-70	70	21×28
	LPO	72-80	54-70	70	21×28
	RAO	72-80	54-70	70	21×28
Pelvis	AP	64-70	50-60	75	33×36
	PA	64-70	50-60	75	33×36

AP: Anteroposterior, LAO: Left anterior-posterior oblique, LLAT: left lateral, LPO: Left posterior-anterior oblique, PA: posteroanterior, RAO: Right posterior-anterior oblique, RLAT: Right lateral, RPO: Right posterior- anterior oblique, SSD: Source to skin distance.

For data collection and interpretation, the researcher devised an assessment form with 346 entries to facilitate the comparison between the international dose standards and the doses administered. The data collection involved input from various technologists to ensure a diverse and representative sample, minimizing the potential for bias. The collected data encompassed examinations discussed earlier, creating a comprehensive dataset for the comparative analysis.

In the subsequent data analysis phase, statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS) version 20. Coding responses and entering them into the program allowed for the expression of continuous variables as means, while frequencies and percentages were calculated for categorical variables. The Wilcoxon signed ranks test was employed for pairwise comparisons between two sequences, providing a robust statistical method for assessing the significance of differences in the doses administered compared to the recommended standards.

3. Result

The sample for this study comprises 350 patients, encompassing both genders and varying age groups. The demographic characteristics reveal that 62.6% of the sample is male, while 37.4% is female. In terms of age distribution, 42.2% are less than 20 years old, 19.9% fall between 20 and 35 years, and 37.9% are over 35 years old. The distribution provides a comprehensive representation of patients for the analysis.Table 2 outlines the distribution of image names within the sample, with frequencies and percentages. Notably, the images include abdomen, chest, elbow (AP), lower extremity, skull, spine, and upper extremity. Each image type is associated with varying frequencies, contributing to the diversity of the dataset. The table presents a clear overview of the distribution of images used in the study.

Table 2: Frequency Distribution of Radiographic Image Types in the Study Sample.

Image name	Frequency	Percent
Abdomen	23	6.6%
Chest	98	28.0%
Elbow (AP)	8	2.3%
Lower extremity	91	26.0%
Skull	29	8.3%
Spine	36	10.3%
Upper extremity	65	18.5%
Total	350	100.0%

In investigating the relationship between the target Exposure Index (EXI) and the current EXI. The one-sample t-test is employed to examine this hypothesis, using a default average value of 2.5. Table 3 displays the results of the t-test, indicating that the mean current EXI is 2.42 with a standard deviation of 9.95. The t-test value is -0.153 with 349 degrees of freedom, resulting in a p-value of 0.88. Based on these results, the null hypothesis is accepted, indicating no statistically significant difference at the specified significance level, $\alpha <= 0.05$, with regard to the current EXI.

Table 3: One sample t-test to test the significant of current EXI compared by the default average value =2.5.

Variable	N	Mean	Std. Deviation	t-test	d.f	significant
Current EXI	350	2.42	9.95	-0.153	349	0.88

In exploring the relationship between the study's Kilovoltage Peak (kVp) and Bontrager's kVp. The impact of KVP, distributed according to Bontrager, is examined through mean scores, as depicted in Table 4. The table presents the distribution of mean kVp scores across various kVp ranges, providing insight into the potential differences.

Table 4: Means of the level impact of KVP distributed by Bontrager.

KVP	N	Mean	Std. Deviation
50-55 kvp	15	52.27	3.081
60-65 kvp	23	53.17	4.599
60-70 kvp	36	55.11	5.22
65-70 kvp	23	53.43	5.566
65-75 kvp	2	53	4.243
70-75 kvp	22	53.55	6.681
70-80 kvp	14	65.07	7.641
70-85 kvp	7	66.86	6.23
75-80 kvp	20	58.7	4.985
75-85 kvp	15	75.07	10.846
80-85 kvp	46	68.87	10.138
80-90 kvp	9	69.78	5.974
85-90 kvp	20	76.4	8.756
110-125 kvp	98	100.73	19.457
Total	350	72.51	22.459

To test the hypothesis, a One-Way Analysis of Variance (ANOVA) is employed to determine significant mean differences due to the impact of kVp, as distributed by Bontrager. Table 5 displays the results of this analysis, showing significant differences in means among participants according to Bontrager. The rejection of the null hypothesis suggests that there are statistically significant mean differences at the 0.05 significance level due to the impact of KVP distributed by Bontrager.

Table 5: Significant differences in mean kVp for independent samples among the participants according to Bontrager book.

Variable	Source of Variation	Sum of Squares	d.f	Mean Square	F	Sig.(P)
kVp	Between Groups	126646.96	13	9742.07	66.28	0.00
	Within Groups	49390.49	336	147.00		
	Total	176037.45	349			

In investigating the relationship between the current Exposure Index (EXI) and the Deviation Index. The examination involves the significant difference between the mean values of the current EXI and Deviation Index, as detailed in Table 6. The table displays the mean and standard deviation for both variables, with the subsequent t-test revealing a p-value of 0.88, leading to the acceptance of the null hypothesis. Consequently, there is no statistically significant difference at the 0.05 significance level between the current EXI and the Deviation Index.

Table 6: Significant relationship between current EXI and deviation index.

Variable	Yes		No		T Value	P Value
	Mean	Standard Deviation	Mean	Standard Deviation		
Current EXI	2.30	1.08	2.47	11.79	-0.15	0.88

Moving on to the relationship between the current Exposure Index (EXI) and image type. The subsequent One-Way Analysis of Variance (ANOVA) results, displayed in Table 7, show no statistically significant mean differences at the 0.05 significance level due to the impact of current EXI distributed by image type. Therefore, the null hypothesis is accepted, indicating that there are no statistically significant differences in the means at the specified significance level.

Table 7: Analysis of Variance for the Impact of Current Exposure Index (EXI) across Different Image Types.

Variable	**Source of Variation**	**Sum of Squares**	**d.f**	**Mean Square**	**F**	**Sig.(P)**
Current EXI	Between Groups	203.10	6	33.85	0.34	0.92
	Within Groups	34375.56	343	100.22		
	Total	34578.67	349			

In examining the relationship between the Exposure Index (EI) and age groups. The evaluation involves mean scores reflecting the impact of the current Exposure Index distributed across different age groups. Subsequently, a One-Way Analysis of Variance (ANOVA) is employed to identify any significant mean differences due to the impact of the current Exposure Index distributed by age. The results, detailed in Table 8, indicate that the null hypothesis is accepted, signifying no statistically significant mean differences at the 0.05 significance level based on the impact of the current Exposure Index distributed by age.

Table 8: Significant differences with means of the level impact of current EXI distributed by age.

current EXI	N	Mean	Std. Deviation
less than 20 years	146	3.00	15.24
between 20 and 35 years	69	2.01	1.77
more than 35 years	131	2.01	2.15
Total	346	2.43	10.01

Variable	Source of Variation	Sum of Squares	d.f	Mean Square	F	Sig.(P)
current EXI	Between Groups	82.26	2	41.13	0.41	0.67
	Within Groups	34493.57	343	100.56		
	Total	34575.84	345			

Moving on to acceptance by radiologic technologists and acceptance through the Deviation Index (DI). The examination involves a Pearson correlation to identify any significant differences between these two acceptance methods. As shown in Table 9, the results lead to the rejection of the null hypothesis, indicating statistically significant differences at the 0.05 significance level. The Pearson correlation coefficient of 0.585 signifies a significant relationship between acceptance by radiologic technologists and acceptance through the Deviation Index.

Table 9: Significant Pearson difference between accepted by radiologic technologist and accepted through DI.

Variables	Pearson Correlation	P Value
Accepted by radiologic technologist and accepted through DI	.585**	0.00

These findings shed light on the interplay between the Exposure Index and age groups, as well as the differing perspectives on acceptance held by radiologic technologists and the Deviation Index, providing valuable insights into the factors influencing acceptance decisions in radiography.

4. Discussion

The results of the hypotheses testing provide valuable insights into the practices and decision-making processes of radiologic technologists (RTs) in the context of radiography. The first hypothesis aimed to assess whether there are statistically significant differences in the current Exposure Index (EXI). The acceptance of the null hypothesis indicates that, at the 0.05 significance level, there is no significant difference in the current EXI. This suggests that radiation technologists are adept at using appropriate parameters, resulting in an accepted exposure index. This finding aligns with similar studies, such as the official report of the American Academy of Oral and Maxillofacial Radiology, reinforcing the robustness of the current study's outcomes (Junda et al., 2021; Suliman et al., 2021)

The second hypothesis investigated potential differences between study Kilovoltage Peak (kVp) and Bontrager's kVp. The rejection of the null hypothesis implies the existence of statistically significant mean differences between these two variables. However, these differences did not have a direct impact on the exposure index. The study suggests that the automatic exposure controls, which determine kVp and mas as defaults without RTs' interpretation, might contribute to this discrepancy. Adjusting parameters based on patient characteristics is crucial, as supported by findings in other studies, such as the examination of automatic exposure control regimes for digital radiography systems (Kaushik et al., 2021).

Hypothesis 3 explored the relationship between the current EXI and the deviation index. The acceptance of the null hypothesis indicates that there are no statistically significant differences between the current EXI and the deviation index. This aligns with the findings of previous hypotheses, suggesting that changes in kVp did not significantly alter the exposure index. The study emphasizes the consistency between the current and target EXI, reinforcing the validity of the results.

Hypotheses 4 and 5 investigated the impact of current EXI on image type and gender, respectively. The acceptance of both null hypotheses implies that there are no statistically significant mean differences due to the impact of the current EXI distributed by image type or gender. This underscores the logical correlation between the type of image and the parameters (kVp and mAs) used, leading to distinct exposure indices for each image type. Similarly, the minimal differences between genders, as supported by relevant studies, have no significant impact on the exposure index. Hypothesis 6 focused on age as a potential factor influencing the current EXI. The acceptance of the null hypothesis indicates that there are no statistically significant mean differences due to the impact of the current EXI distributed by age. The study emphasizes the uniform effect of age across genders, further strengthening the findings related to gender differences.

The final hypothesis explored the relationship between acceptance by radiologic technologists and acceptance through the Deviation Index (DI). The rejection of the null hypothesis suggests a statistically significant relationship between the two, with a correlation coefficient of 0.585. The study postulates that the human eye's limited ability to distinguish shades of gray may contribute to the difficulty in discerning accepted and rejected images, highlighting the importance of incorporating algorithms for accurate assessments.

In conclusion, the study's results contribute to our understanding of the nuanced factors influencing exposure indices in radiography, highlighting the proficiency of radiation technologists, the impact of automatic controls, and the significance of parameters based on patient characteristics.

4. Conclusion

This research provides valuable insights into the practices of radiation technologists in a specific healthcare context. The study highlights the need for continued education on interpreting automatic exposure controls, emphasizing the impact on exposure settings. The logical correlation between parameters and exposure indices supports the importance of tailored approaches for different image types. The significant relationship between acceptance methods underscores the challenges technologists face in visually assessing images accurately. Overall, these findings contribute to enhancing the efficiency and accuracy of radiographic practices in clinical settings.

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