The Optimal Dosage of Radiation

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INTRODUCTION

X-rays are a form of electromagnetic radiation and pass through most objects, so x-rays are used to take scans of the body for medical purposes. However, when taking these scans, one cannot use just any amount of radiation because it can overexpose or underexpose the patient, creating a bad scan and/or exposing to more radiation than needed. When taking x-rays, there are technical factors one has to consider. They include kVp (kilovoltage peak) and mAs (milliampere-seconds). [1]

After following radiologic technicians around and seeing them work, it was apparent that the amount of technique (mostly mAs) varied based on the patient. If an image came out underexposed or overexposed, the technician would have to adjust the technique at their discretion. Thus, the question of what is the best amount of mAs for certain ranges of body mass indices arised, so this study will mainly focus on mAs and its relationship with the Body Mass Index (BMI) which will both affect the radiation absorbed by the patient.

Key Terms

DI: The deviation index (DI) measures the difference between how many photons should be reaching the image receptor in the relative image region for that particular study and the amount of x-ray photons that actually do reach the image receptor in the relative image region. [2]

kVp: Kilovoltage peak will determine how strong the penetrative power of the x-ray beam is.

mAs: milliampere-seconds is a measure of radiation produced (milliamperage) over a set amount of time (seconds) via an x-ray tube. It directly influences the radiographic density, when all other factors are constant. [3]

BMI: Body Mass Index is a measure of body fat based on height and weight that applies to adult men and women. [4]

Dosage (Radiation dose): More specifically the absorbed dose which is the concentration of energy deposited in tissue as a result of an exposure to ionizing radiation. Simply put, it is the energy absorbed by human tissue. [5]

METHODOLOGY

The investigation will collect data from previous records of patients' scans and height and weight information that are all collected in a database called PAX and Epic. For this investigation we randomly chose patients who received a 2-View Chest scan with no extra scans. That includes the PA (posterior anterior) scan, which is the view from the front to the back of the chest, and a lateral scan which is from the side of the body. (Insert pictures) Another condition on which data from the patients were collected was if the patient was scanned with the "Medium Adult" setting. This setting sets the kVp to 120 while the mAs can change. Since most of the time the technologists don't change the type of adult and rather the amount of technique used, we decided to keep it consistent with that condition. Once both conditions are fulfilled, the patient's information is pulled up and their BMI is collected. If some patients didn't have their BMI automatically calculated then a BMI calculator was used. Afterwards, the amount of mAs for the PA and lateral scan were collected and how over/under exposed the scan was, using the DI scale on the machine. Finally, the dosage was collected. All the data was collected from the same computers in the same x-ray room. The purpose of collecting all those variables is because the 2-view chest scan is the most common scan ordered from doctors for patients and the DI, mAs, and BMI all can affect the dosage which measures the absorbed radiation from both the PA and lateral scan.

RESULTS

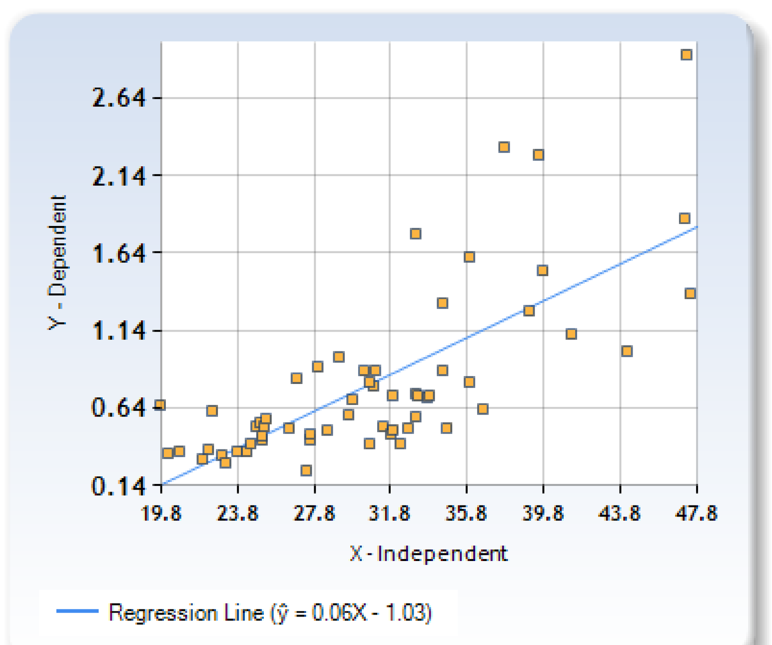

Figure 1: Relationship between BMI (kg/m^2) (x-independent) and dosage (mGy) (y-dependent)

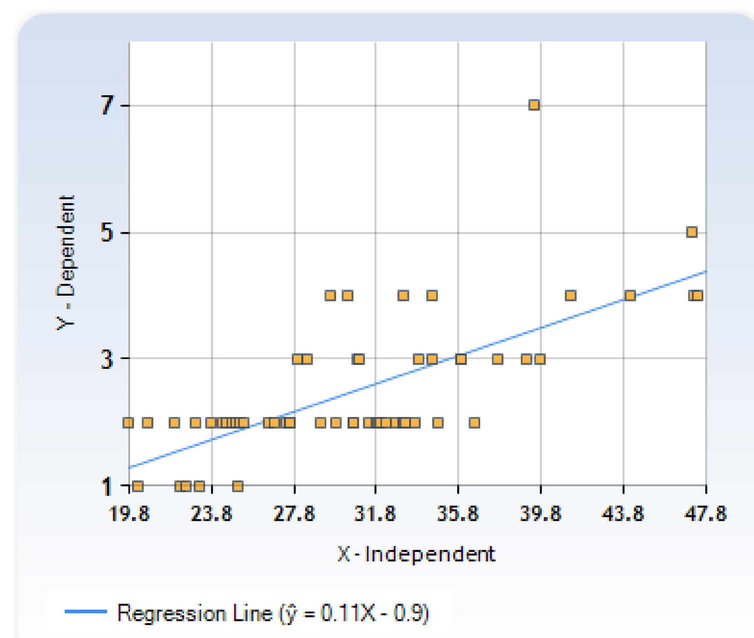

Figure 2: Relationship between BMI (kg/m^2) (x-independent) and mAs (PA scan) (y-dependent)

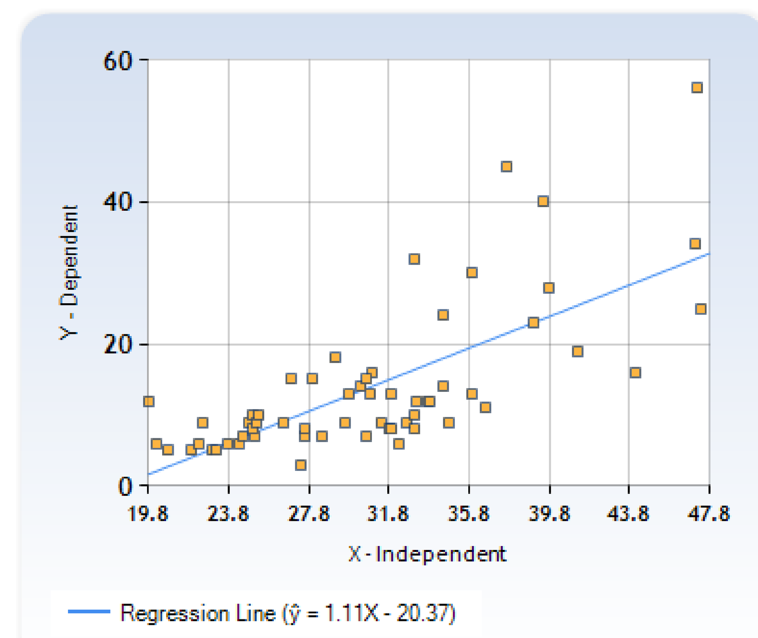

Figure 3: Relationship between BMI (kg/m^2) (x-independent) and mAs (lateral scan) (y-dependent)

Figure 4: Table of means () & standard deviations for the BMI values (kg.m^2) along with the respective dosages (mGy) separated into the different BMI classes

BMI Weight Class	x̄ (kg/m^2)	s	x̄ (mGy)	s
Normal	22.5975r	1.6734	0.4134	0.1224
Overweight	27.1153	1.701	0.5775	1.701
Obese	36.6525	5.0508	1.04925	0.62526

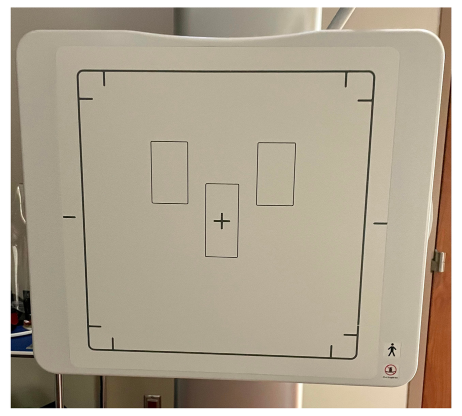

Figure 9: Grid patients stand in front of during most 2-View Chest x-ray scans

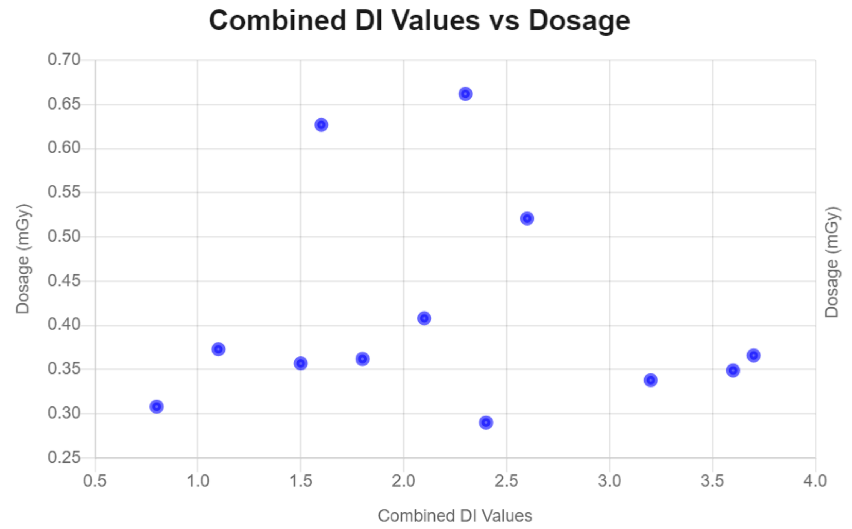

Figure 6: Combined DI Values vs Dosage for Normal BMI Class

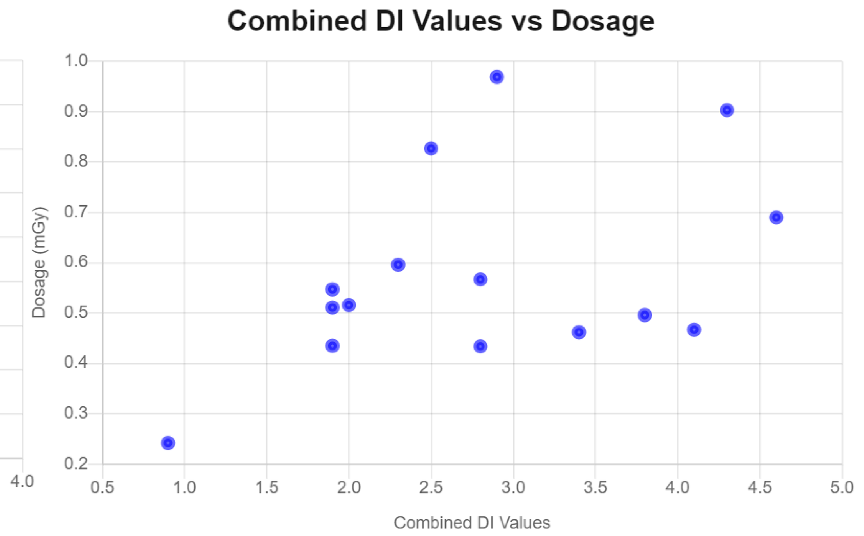

Figure 7: Combined DI Values vs Dosage for Overweight BMI Class

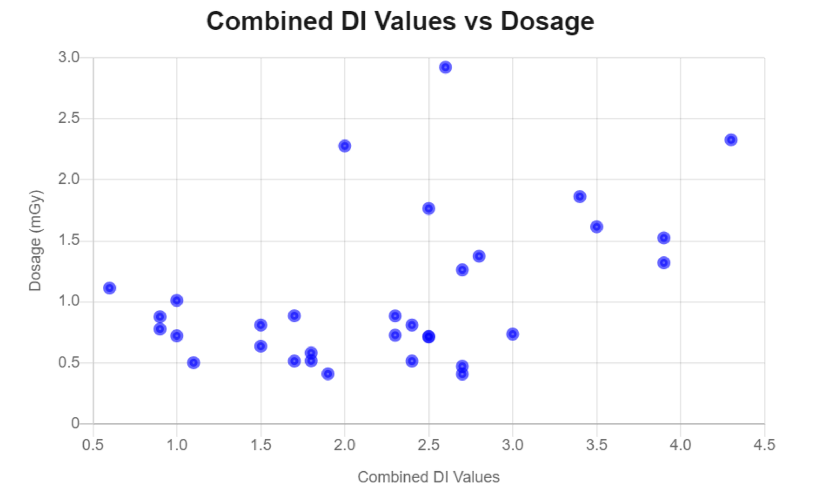

Figure 8: Combined DI Values vs Dosage for Obese BMI Class

CONCLUSIONS/DISCUSSION

Looking at Figure 1, there is a positive and direct relationship between BMI and dosage. The linear regression line looks strong, positive for the indices approximately below 35. Figure 4 separates the data into three categories based on BMI, and there is a difference between the average dosage received by the patients. It mainly jumps once we get to the obese range as this range includes the BMIs of all three classes of obesity. This means that it is important to look at the data organized into different BMI classes. From Figure 1 and Figure 4, BMI is proven to be directly related to dosage. To figure out the best range of mAs from the data that was collected, we have to not only separate the different classes according to the BMI, but also look at the DI closest to 0 and the lowest dosage. To do this, the absolute value of the DI values were added from both scans and then compared to the dosage from the three BMI classes as shown in Figures 5, 6, & 7. We are looking for the lowest & leftmost point. In Figure 5 that ends up being (0.8, 0.308). The mAs for the PA and lateral scans and BMI associated with those values are 2, 5, and 21.97 respectively. In Figure 6, it is (0.9, 0.242). The respective mAs for the PA and lateral scan and the BMI is 2, 3, & 27.41. Finally, in Figure 7 showcasing the values from the obese range, it is (0.9, 0.777) and the respective mAs values for the PA and lateral scan and the BMI are 3, 13, & 30.9. According to our study, we can conclude the best mAs (PA) for the normal, overweight, and obese classes is 2, 2, & 3 respectively, For the lateral it would be 5, 3, & 13 respectively. You may think that it is weird for the optimal lateral mAs value is lower in the overweight class compared to the normal BMI class. This is because there are uncontrollable factors that possibly skewed the data.

Figure 9 shows the grid that the x-ray detects the rays from. On it are three vertical rectangles that only get the true dosage if the patient correctly stands in front of the target rectangles that are being used for a specific scan. For example, a lateral would only use the bottom rectangle in Figure 9, so if a patient were to step a little too forward or backward, then the AEC (Automatic Exposure Control), a device that terminates the exposure to radiation, would end the exposure too fast. In the machine's point of view, there is too much radiation being absorbed and passing through the patient, when in reality it's not hitting the patient at all. In addition, wearing metal can also affect the AEC because metal means the x-ray beam has to be more penetrative in order to get through the metal. So, if patients were wearing metal or not standing in the perfect position, then the data collected would not be representative. Next, BMI calculates a person's body fat with their height and weight. Considering that thickness is the main factor that affects how much radiation needs to pass through someone, a greater BMI does not necessarily mean greater thickness around the chest area.

Finally, if you collect data from past exams, then the mAs will show up rounded. For the chest PA scan this would be a problem because the data isn't variable (Figure 2) when rounded to a single digit, so it's hard to see if BMI truly affects the mAs for that scan. However, looking at Figure 3 you can see how the mAs values for the lateral scans can go to greater numbers, so rounding to a single digit can still help us find patterns and trends.

However, knowing all of these factors, we can take a step closer into finding the true optimal technique with different resources and methods that'll control those factors. This will help us make sure patients are exposed to the least amount of radiation to eradicate any possible long-term effects.

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