TG116 Exposure Index Calibration: Measured Variation as a Function of Beam Quality

B. Luckett[1], V. Garcia[1],D. Gauntt[2],I.B. Rutel[1]

[1] University of Oklahoma Health Science Center, Oklahoma City, OK

[2] University of Alabama at Birmingham Medical Center, Birmingham, AL

JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING

EASTERN TIME [GMT-4]

INTRODUCTION

Exposure Indices (EI) are designed to give an insight to the exposure to the imaging plate during digital radiography exams. These are vital values because they allow technologists to judge proper exposure and aid in the prevention of over exposure to patients. Because these EI values are utilized for quality of imaging, its prudent that medical physicists validate their accuracy. Task Group report 116 provides guidelines for testing EI values with the aim of achieving consistent and reliable results. This study assesses the span of beam quality and beam quantity deemed acceptable by TG 116 for EI evaluation.

AIM

The purpose of this study is to asses the guidelines of TG 116 by evaluating Exposure Index values which span the range of acceptable beam quality and quantity accepted by TG 116. Additionally, we investigate any potential limitations or complications in evaluating EI values in digital radiography imaging systems.

METHOD

- To begin this study, combinations of kVp, HVL, and added filtration were determined, adhering to the ranges deemed acceptable by TG 116 (Figure 1).
- These ranges allow for kVp between 66 and 74 kVp with HVL values between 6.55 to 7.05 mm of Aluminium[1].
- Added filtration could include 0.5 mm of Copper with up to 4 mm of additional Aluminium[1].
- For each exposure value, kVp, HVL, and filtration combination available, we recorded the Exposure Index
- For this experiment a Fuji FDR Go portable radiography system was used for making exposures and an FDR D-EVO II DR (GOS) receptor for providing exposure information, including the exposure EI values.

RESULTS

In the presented figures we show deviations from expected behavior for the EI. First, for our plot of EI with respect to exposure (Figure 2), we observe that at around 1.5mR, there appears to be a differentiation in linearity. When separating these sample points, and taking a least squares linear fit, we found that below 1.5mR, the slope was 901.69 EI/mR with an R-squared value of 0.9966, and above 1.5mR, the slope was 288.63 EI/mR with an R-squared value of 0.9997.The dose-response curve is linear up to 1.5mR in all TG116 acceptable combinations of beam spectrum (green boxes in Figure 1).

Additionally, we investigated the trend of EI/mR as a function of exposure, across all accepted beam spectra. Because EI is expected to be linearly proportional to exposure (since the vendor utilizes a single point calibration), we expect EI/mR for the experimental data to be constant across the exposure range, ideally, with no values lying outside of the +/-10% tolerance bounds (10% is defined by the vendor's acceptable EI variability).

Looking at Figure 3, we see that this is not the case. There appears to be a slight increase in normalized EI as exposure rises from 0.5mR to 1.0mR and then a significant decrease in normalized EI from 1.0mR to 2.0mR. This nonlinearity contributed to 17% of EI values failing the +/-10% tolerance. This is an area for concern in testing EI values, since what are expected to be valid conditions would provide failing EI calibration results. In continuing this investigation, we endeavor to identify beam spectrum qualities that would give consistent results in evaluating EI values.

	kVp								
Filtration	66	67	68	69	70	71	72	73	74
0.5 mm Cu	No	No	No	No	No	No	No	No	Yes
0.5 mm Cu + 1 mm Al	No	No	No	No	No	No	No	Yes	Yes
0.5 mm Cu + 2 mm Al	No	No	No	No	No	No	No	Yes	Yes
0.5 mm Cu + 3 mm Al	No	No	No	No	No	No	Yes	Yes	Yes
0.5 mm Cu + 4 mm Al	No	No	No	No	Yes	Yes	Yes	Yes	No

Figure 1. The table shows the process in finding acceptable HVL and kVp combinations. This work spans the 66 to 74 kVp range across the acceptable filtration combinations with 1mm Aluminium steps in added filtration. "Yes" indicates the kVp/filter combination results in an acceptable HVL.

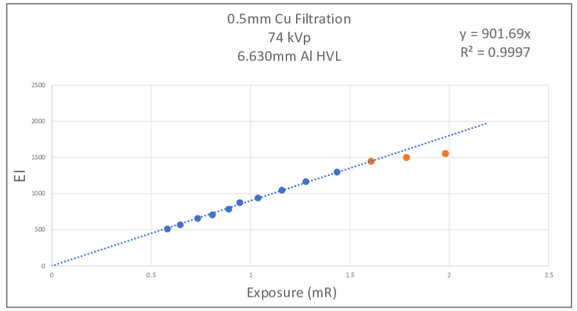

Figure 2. In the figure above, there is an observable deviation away from the expected proportionality of EI per exposure (orange data points). When fit to a proportional least squares model (with intercept set to the origin), there appears to be two distinguishable relationships between EI and exposure, the second emerges when exposure exceeds 1.5 mR.

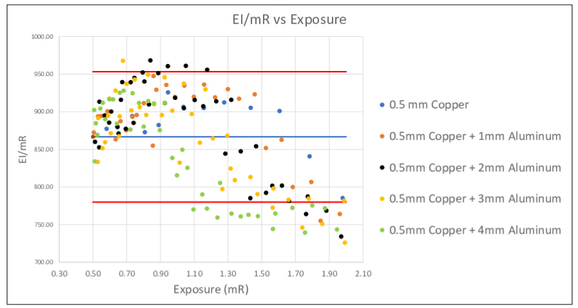

Figure 3. This plot shoes the EI per mR across all experiments. The top and bottom red lines show the 10% tolerance above and below the expected value, and provide the passing range for EI values for this vendor. There appears to be some relation between added filtration and the overall trend of EI values across the range of exposures.

CONCLUSIONS

This study shows that the beam spectrum conditions of TG 116 may be too broad for consistent evaluation of EI values. The results display some nonlinear characteristic of EI with respect to exposure, as well as potentially unwarranted failures in EI calibration. From this experimental data, it can be concluded that the range of exposure is, at a minimum, too broad for consistent results, and exposure should be contained to <1.5mR for EI testing.

The next step to take in progressing with this study is to investigate the Exposure Index response to TG116 spectra across multiple diagnostic systems and vendors. As this study was completed using only one DR product from a single vendor (using multiple vendor x-ray units), the question is raised as to whether the non-linear behavior is specific to the vendor or is more general to the industry.

REFERENCES

[1]Shepard SJ, Wang J, Flynn M, et al. An exposure indicator for digital radiography: AAPM Task Group 116 (executive summary) [published correction appears in Med Phys. 2010 Jan;37(1):405]. *Med Phys.* 2009;36(7):2898-2914. doi:10.1118/1.3121505

CONTACT INFORMATION

Brandon-luckett@ouhsc.edu