Heel Effect and its kVp Dependence in Mammography

Authors: Victor Garcia, Caleb Stallcup, Weiyuan Wang
The University of Oklahoma Health Sciences Center, Oklahoma City, OK

The University of Oklahoma Health Sciences Center

JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

INTRODUCTION

Heel effect is a known phenomenon in X-ray imaging. However, the effect of kVp on the Heel effect in the mammographic energy range is relatively unknown. The Heel effect should be investigated for different kVp values and different target/filter combinations.

AIM

The aim of this poster was to investigate the Heel effect in Mammography, and see the effects of kVp and Target/Filter on it.

METHOD

Using a Hologic Selenia Dimensions mammography unit, a Radcal 10X6-6M ion-chamber was positioned at 2.2cm (Figure 1), 8.2cm, 14.2cm, and 20.2cm from the chest edge (position to center of chamber). When the position is 2.2cm, the ion chamber edge is aligned with the chest wall edge of the image receptor. For these positions, different target/filter combinations (W/Rh, W/Ag, and W/Al) were used to find the exposure for various kVp (20-39kVp for W/Rh and W/Ag; 20-49kVp for W/Al). The ratio was found for the exposures at the different positions to exposure at the 2.2cm, and compared across the different kVp. A second-order polynomial fit was used to extrapolate the data to 22.4cm (center of chamber at anterior edge of image receptor for chamber plane) for all target/filter combinations.

RESULTS

The relative exposures were plotted for all target/filter combinations and for various kVp values (Figure 2, 3, 4). The 2.2cm exposure is very close to that of the chest wall edge. Exposure decreases, due to Heel effect, to about 34.63% to 43.03% of the 2.2cm value for the different target/filter combinations. For W/Rh (Figure 5,6) and W/Ag (Figure 7,8), the relative exposure increases for the increasing kVp values, peaks around 25kVp, and decreases past 25kVp when looking at a fixed distance (8.2cm, 14.2cm, and 20.2cm) from the chest edge. The relative exposure decrease past 25kVp may be due to the k-edge of Rh (23.19keV) and Ag (25.49keV). The deviation, which is the maximum minus the minimum divided by the average, ranges from 0.94% for 8.2cm (Figure 6), 2.88% for 14.2cm, 6.00% for 20.2cm for W/Rh, and calculated at 8.95% for 22.4cm. The deviation for W/Ag ranges from 0.79% for 8.2cm (Figure 8), 2.45% for 14.2cm, and 4.90% for 20.2cm, and 7.55% for 22.4cm. For W/Al (Figure 9,10), the relative exposure increases with kVp until 35kVp, where it dips, and then begins increasing again past 40kVp for a fixed distance. The deviation for W/Al ranges from 1.37% for 8.2cm (Figure 10), 3.66% for 14.2cm (Figure 11), and 8.57% for 20.2cm (Figure 12), and 13.17% for 22.4cm.

RESULTS

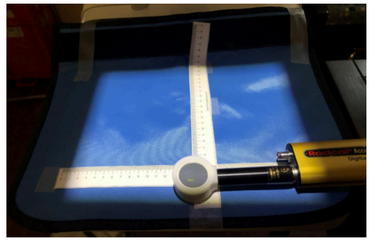

Figure 1. Setup for taking exposures.

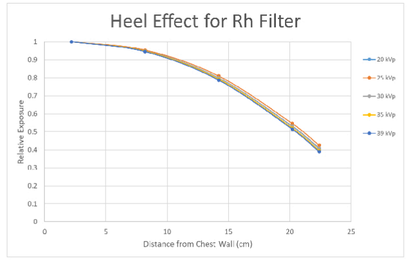

Figure 2. Heel effect for W/Rh at different kVp. The last point at 22.4 cm is the extrapolated data to edge of image receptor.

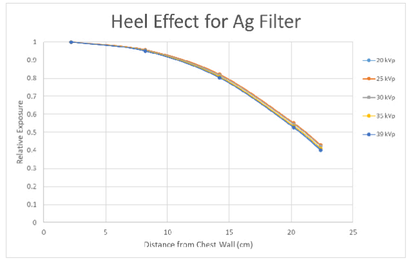

Figure 3. Heel effect for W/Ag at different kVp. The last point at 22.4 cm is the extrapolated data to edge of image receptor.

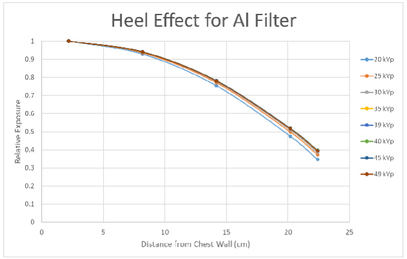

Figure 4. Heel effect for W/Al at different kVp. The last point at 22.4 cm is the extrapolated data to edge of image receptor.

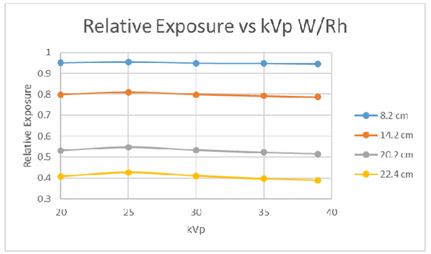

Figure 5. Relative exposure vs. kVp at different positions for W/Rh. The 22.4 cm curve is the extrapolated data to edge of image receptor.

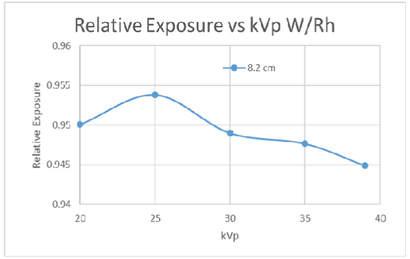

Figure 6. Relative exposure vs. kVp at 8.2 cm for W/Rh.

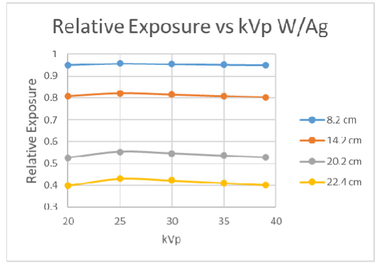

Figure 7. Relative exposure vs. kVp at different positions for W/Ag. The 22.4 cm curve is the extrapolated data to edge of image receptor.

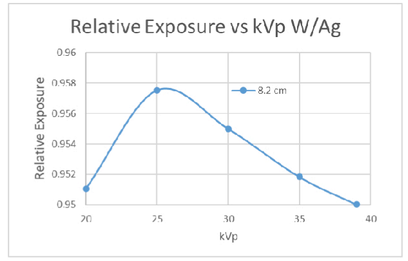

Figure 8. Relative exposure vs. kVp at 6 cm for W/Ag.

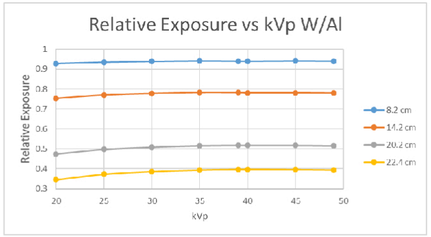

Figure 9. Relative exposure vs. kVp at different positions for W/Al. The 22.4 cm curve is the extrapolated data to edge of image receptor.

RESULTS

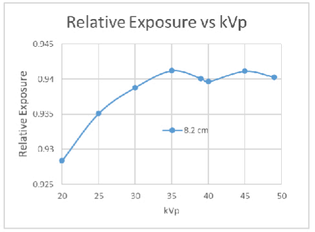

Figure 10. Relative exposure vs. kVp at 8.2 cm for W/Al.

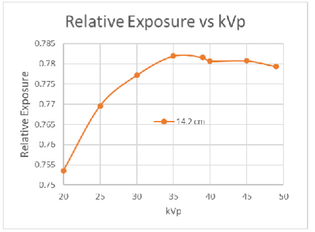

Figure 11. Relative exposure vs. kVp at 14.2 cm for W/Al.

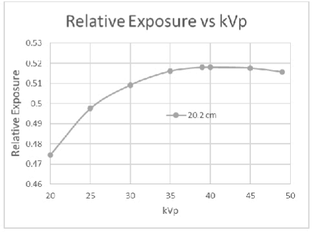

Figure 12. Relative exposure vs. kVp at 20.2 cm for W/Al.

CONCLUSIONS

The Heel effect was found to have a dependence on the kVp for various mammography target/filter combinations. The relative exposure at the anterior edge of the image receptor ranges from 34.63% to 43.03%. For W/Rh and W/Ag, the relative exposure peaked at 25kVp for a fixed distance for all distance measurements. For the W/Al, there is a dip in relative exposure at 35kVp. It is also unclear why there is this dip at this kVp. It is suspected to be caused by the k-edge of the filter material, however further investigation should be done.

CONTACT INFORMATION

Victor Garcia; Weiyuan Wang
Victor-Garcia@ouhsc.edu; Weiyuan-Wang@ouhsc.edu