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Estimation of Staff Scatter Dose Reduction with a Region of Interest (ROI) Attenuator for Fluoroscopically Image-Guided Interventional Procedures

Martina P. Orji*, S.V. Setlur Nagesh, Stephen Rudin, Daniel R. Bednarek
University at Buffalo, Canon Stroke and Vascular Research Center, Buffalo, NY, United States

PURPOSE / OBJECTIVES

- Reducing the x-ray intensity in the peripheral x-ray field using a region of interest (ROI) attenuator and image processing (Figure 1) can reduce the scatter dose to the staff while reducing the dose to the patient.[1]
- In this work, we present the benefit of using an ROI attenuator as a means for staff scatter-dose reduction during fluoroscopically guided interventional procedures, with the advantage of ROI imaging over beam collimation of providing full-field image information

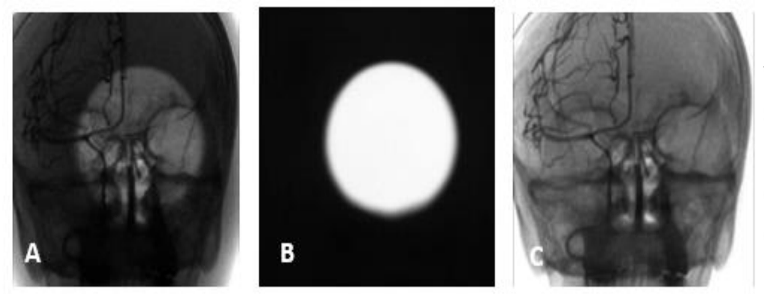

Fig. 1. (A) Head image acquired with an ROI attenuator with a circular hole and about 20 % transmission factor showing the periphery with reduced intensity due to reduced dose. (B) Mask image of the ROI attenuator derived by CNN from Figure 1A. (C) Final brightness corrected, and noise reduced image obtained from Figure 1A using the mask of Figure 1B.[2]

MATERIALS & METHODS

- A 0.7 mm thick copper ROI attenuator with a circular central hole was added to the filter wheel of a Canon C-Arm system so that it could be automatically selected.
- With a 54 cm source-to-skin distance, a 5.4 cm diameter ROI was projected onto the entrance surface of a Kyoto anthropomorphic phantom in the head, chest, and abdomen regions. Measurements of scattered radiation from the phantom were made with and without the ROI filter in place using a 150 cc Keithley ionization chamber and PTW electrometer.
- An 8 x 8 cm and a 15 x 15 cm-square collimated entrance FOV was used for exposures of the head and torso, respectively. The 150 cc ionization chamber was placed on a stand at a height of 150 cm (eye level) from the floor and 50 cm lateral from the patient-table centerline (isocenter) and measurements were made at different positions along the length of the table (distance given in the Results is relative to the beam isocenter).
- Scatter dose per entrance air kerma (EAK) and scatter reduction factors for the ROI attenuator were determined as a function of staff position, beam energy and gantry angulation (Figure 2). All the measurements were done with staff positions at the right side of the phantom.

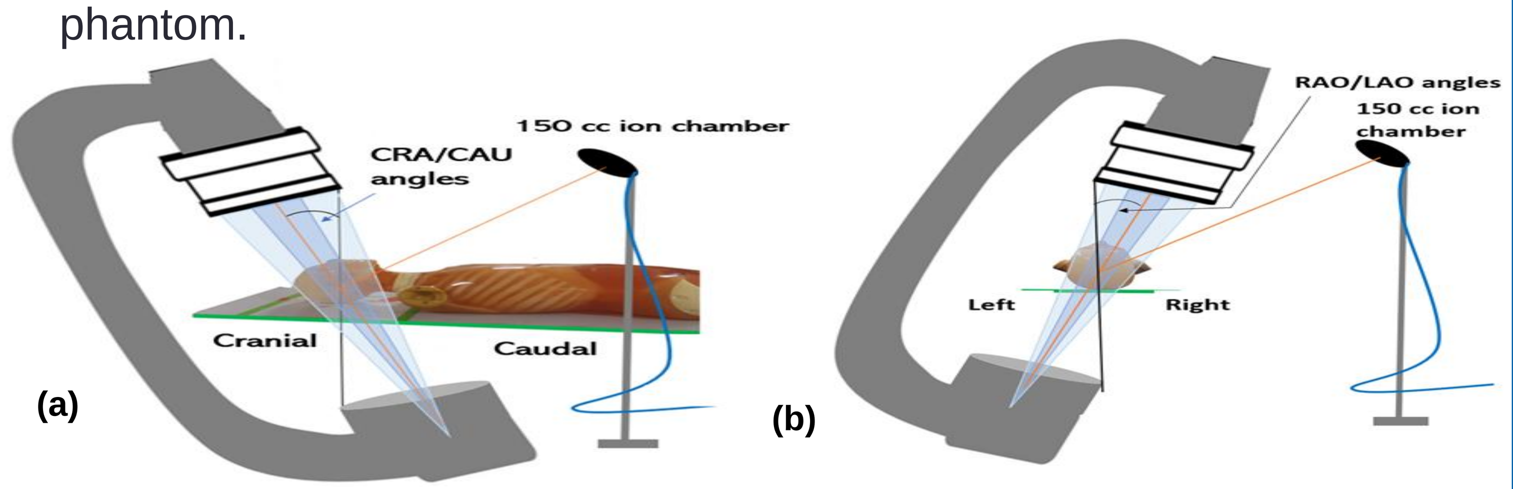

Fig. 2: Gantry angles and scatter dose measurement setups a) CRA/CAU and b) RAO/LAO

RESULTS

1. Scatter dose to staff from phantom - Head Imaging

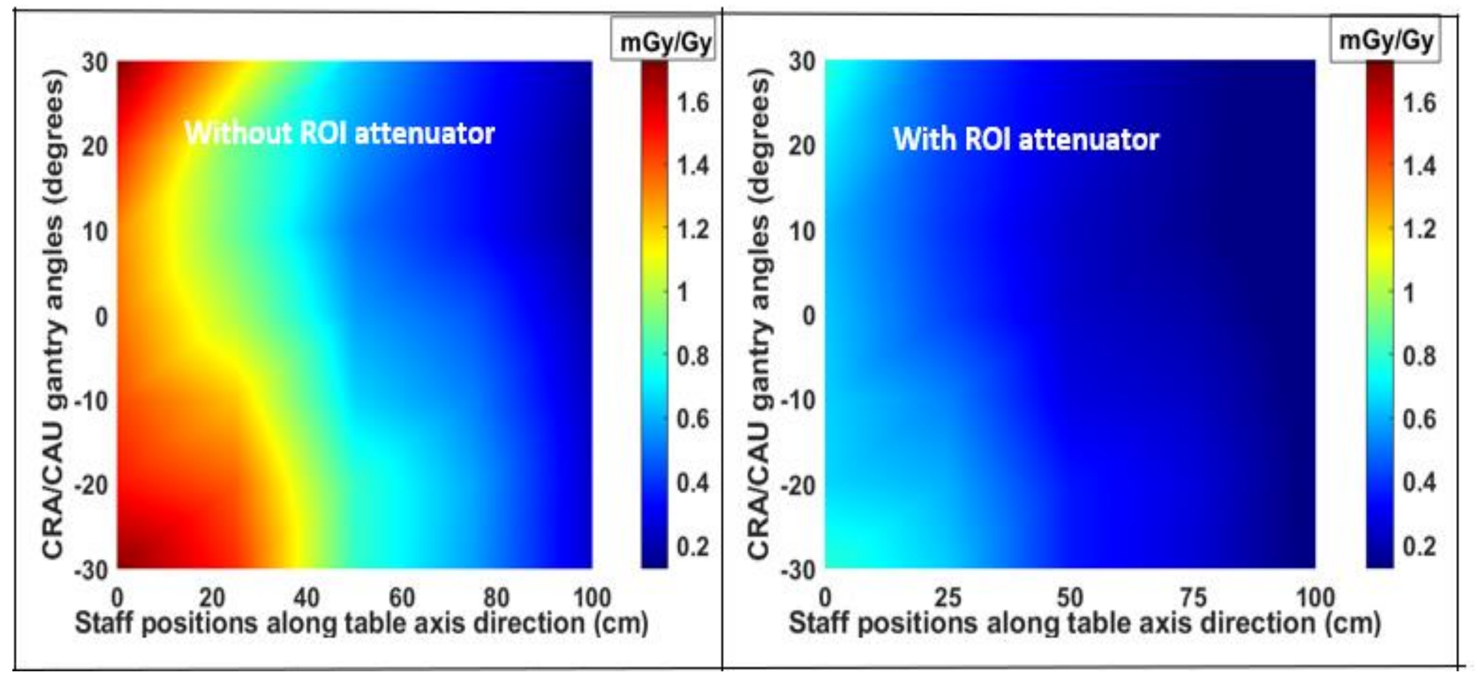

Fig. 3: Scatter dose map for CRA/CAU gantry angles (0 to -30 / 30) vs staff positions at 80 kvp.

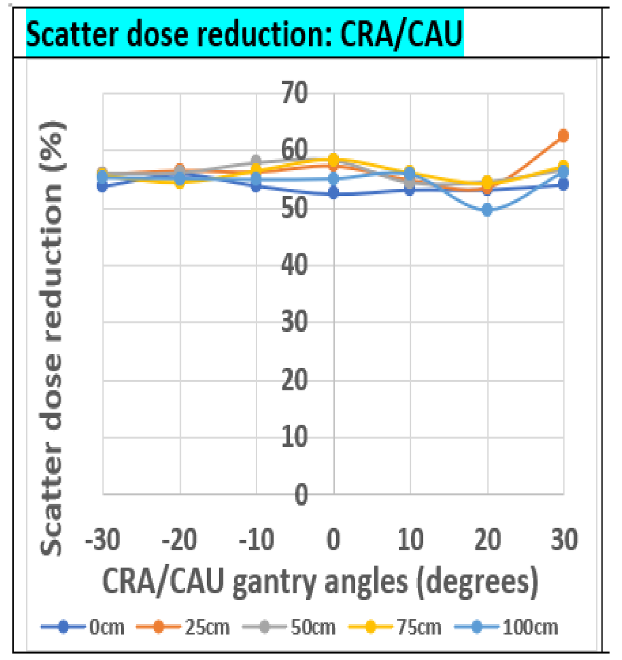

Fig. 4: % Scatter dose reduction vs CRA/CAU angles at different staff positions shown in the legend.

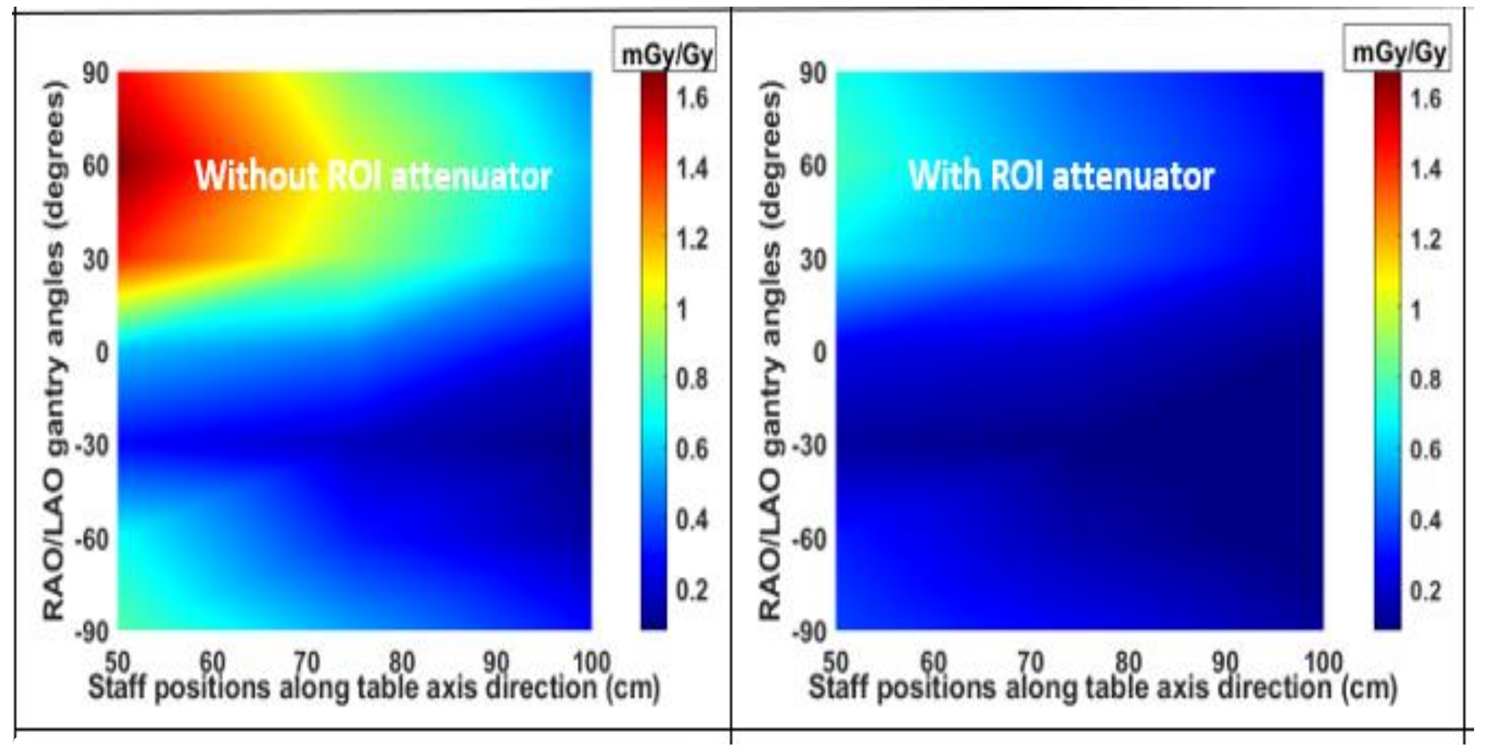

Fig. 5: Scatter dose map for RAO/LAO gantry angles (0 to -90 / 90) vs staff positions at 80 kvp.

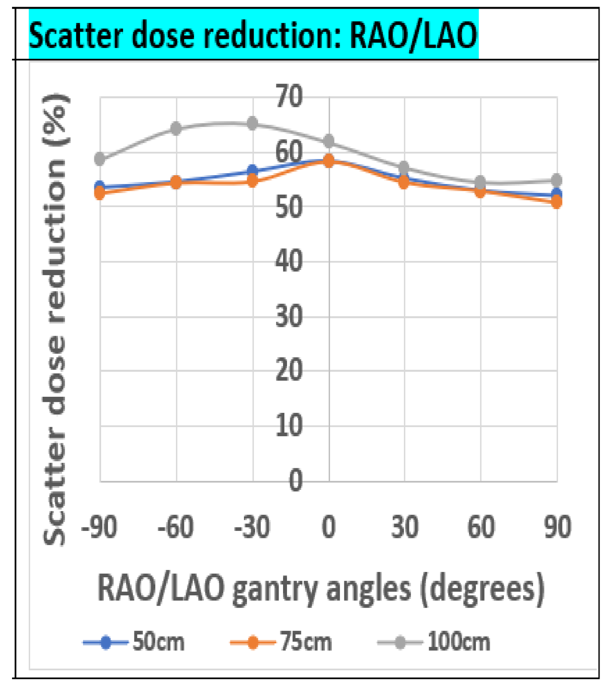

Fig. 6: % Scatter dose reduction vs RAO/LAO angles at different staff positions shown in the legend.

2. Scatter dose to staff from phantom - Chest Imaging

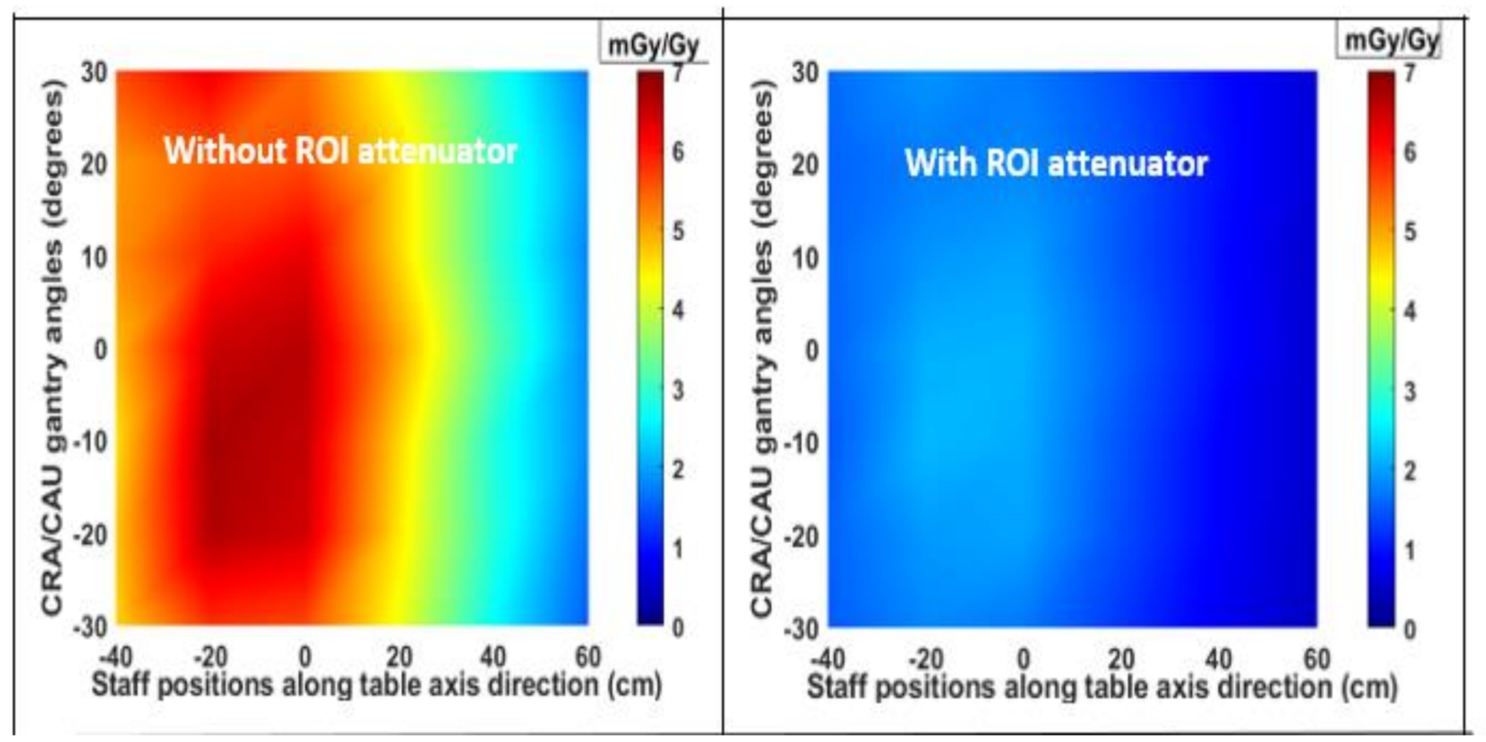

Fig. 7: Scatter dose map for CRA/CAU gantry angles (0 to -30 / 30) vs staff positions at 80 kvp.

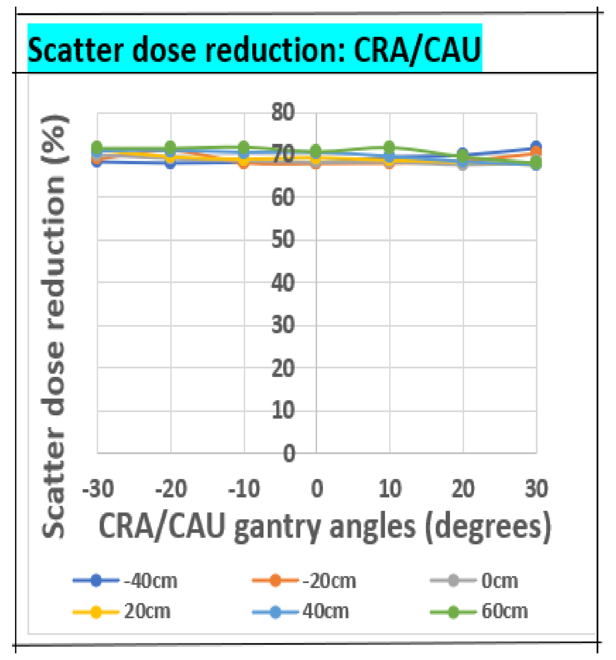

Fig. 8: % Scatter dose reduction vs CRA/CAU angles at different staff positions shown in the legend.

RESULTS CON'TS

3. Scatter dose to staff from phantom - Abdomen Imaging

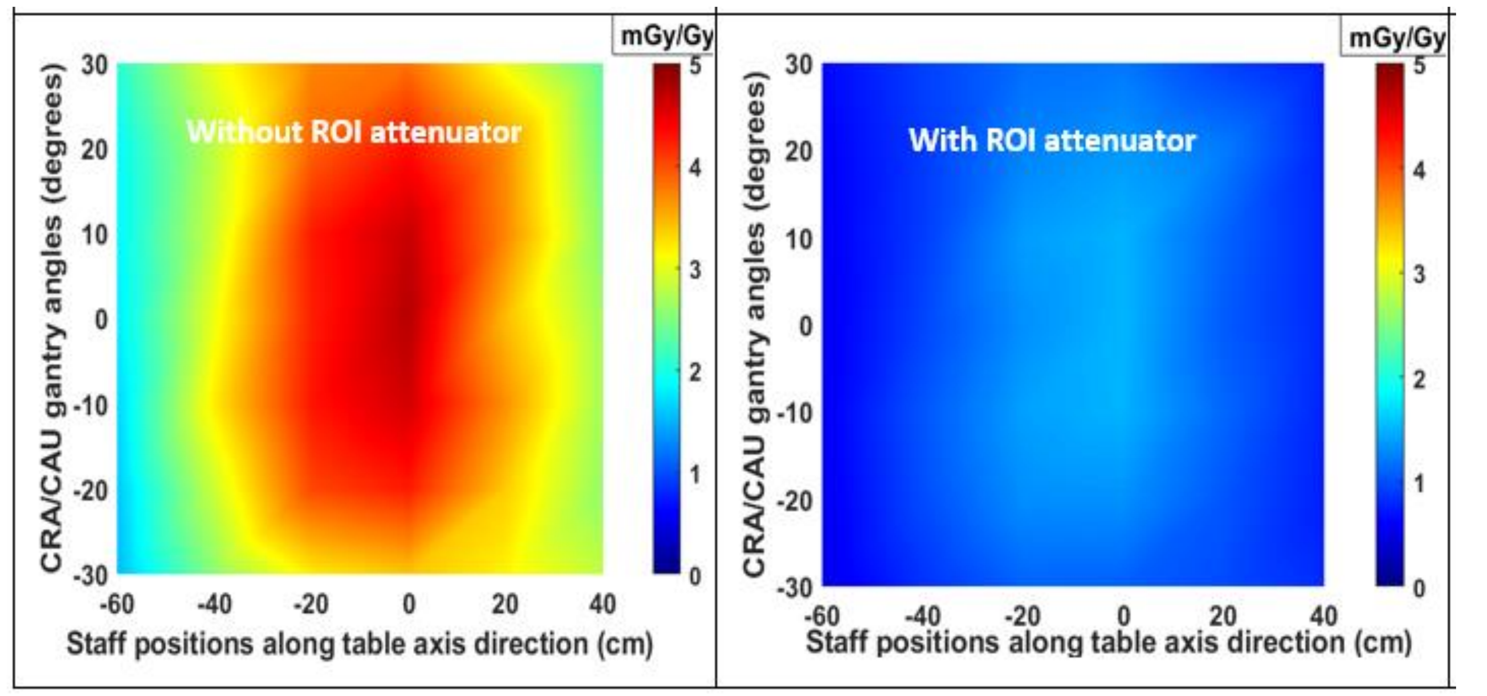

Fig. 9: Scatter dose map for CRA/CAU gantry angles (0 to -30 / 30) vs staff positions at 80 kvp.

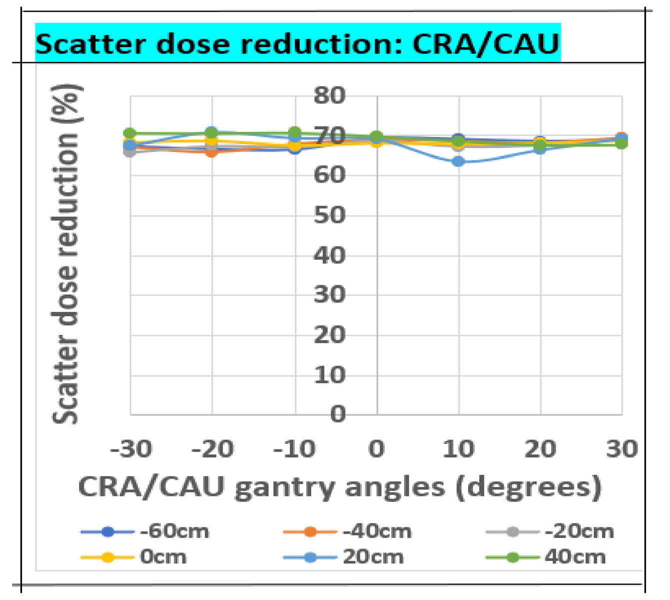

Fig. 10: % Scatter dose reduction vs CRA/CAU angles at different staff positions shown in legends

4. kVp Dependence of Scatter Dose Reduction

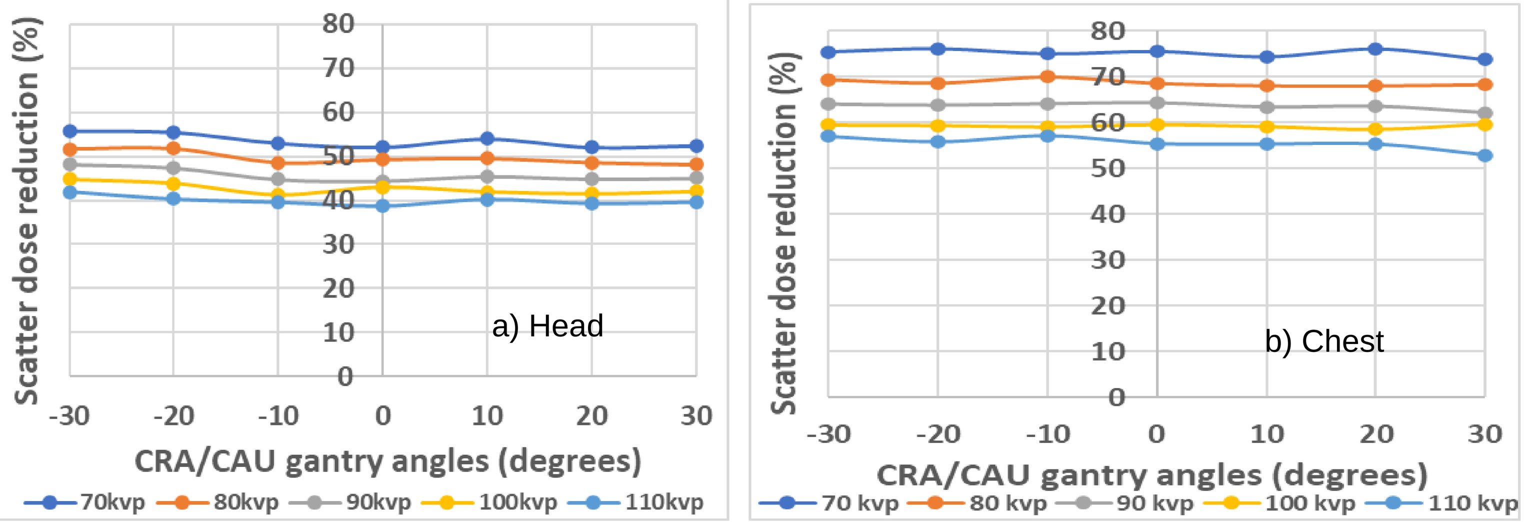

Fig. 11: % Scatter dose reduction vs CRA/CAU angles at different kvp's, at 0 cm along table axis and 50 cm from table centerline. (a): Head imaging, (b) Chest imaging

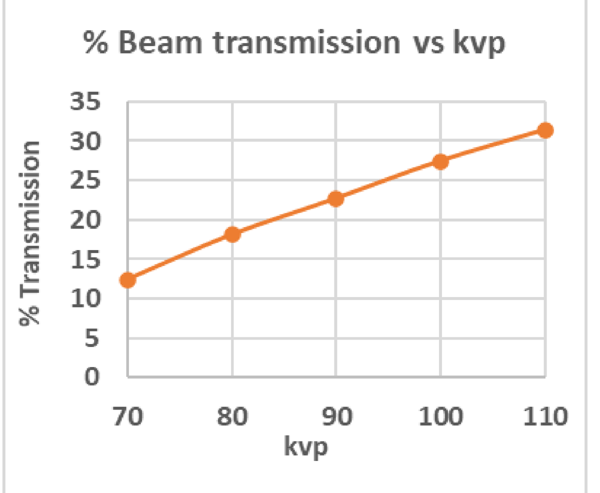

Fig. 12: Percent beam transmission through the attenuator vs kVp

SUMMARY AND CONCLUSIONS

- Staff standing at 50 cm from the table centerline would receive an overall dose reduction at eye level of about 50-60 % for head imaging and 70% for chest and abdomen imaging at 80 kVp when using an ROI attenuator with about 20% beam transmission for all gantry angles.
- The dose reduction goes down with increasing kVp for a fixed ROI attenuator as the transmission factor increases and is nearly independent of CRA/CAU angle.
- The use of an ROI attenuator can provide a substantial reduction of scattered radiation to the interventional room staff without limiting the displayed FOV.

REFERENCES

1. Rudin S, Bednarek DR. Region of interest fluoroscopy. Med Phys. 1992 Sep-Oct;19(5):1183-9 doi: 10.1118/1.596792.
2. S. V. Setlur Nagesh, A. Podgorsak, J. Krebs, D. R. Bednarek, S. Rudin, "Image processing using Convolutional Neural Network (CNN) for Region of Interest (ROI) fluoroscopy," Proc. SPIE 11317 Medical Imaging 2020: Biomedical Applications in Molecular, Structural, and Functional Imaging, 1131718 (28 February 2020); https://doi.org/10.1117/12.2549242

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*Contact Information - Author email: mporji@buffalo.edu