An AI Enabled Dynamic Coning System Reduces Radiation Dose During Fluoroscopy

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Background

Reducing the size of the radiated field ("coning") significantly decreases the radiation dose to both patient and medical staff during fluoroscopic procedures. Even with excellent coning, the physician's attention is typically focused on a small part of the monitor image, e.g. where there is movement of a catheter. The remainder of the irradiated field is essential for orientation.

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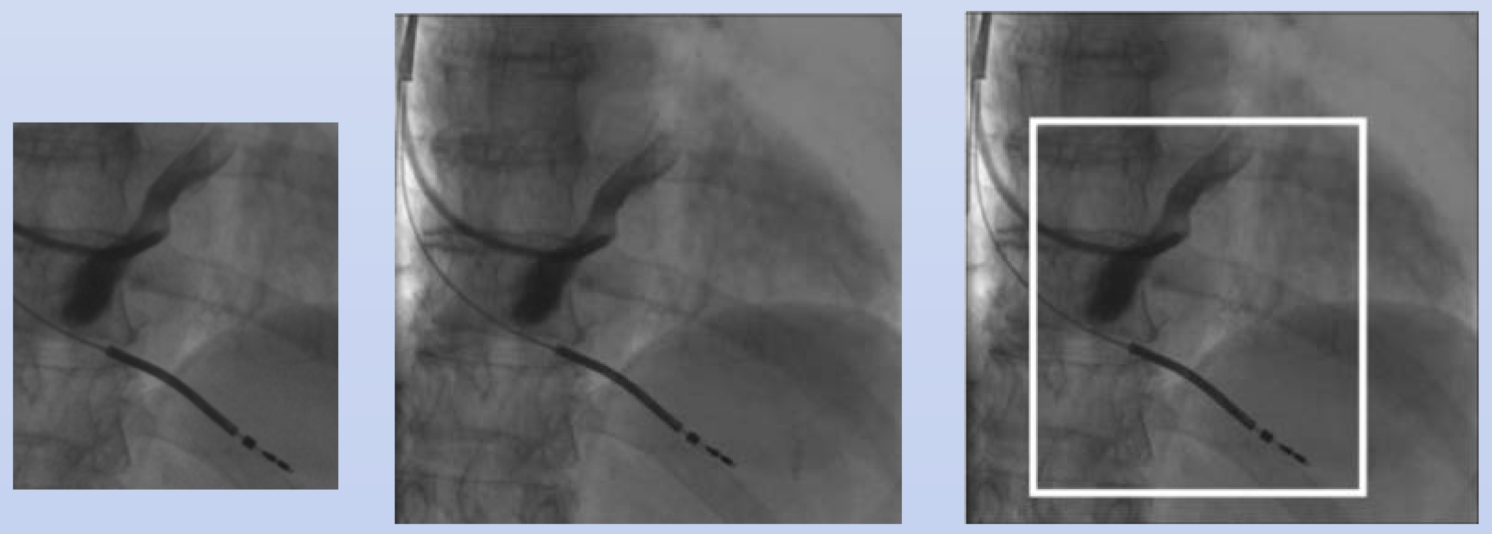
Objective

To demonstrate that continuous sub-second coning and image blending enabled by artificial intelligence (AI) during fluoroscopy will reduce the radiation dose required to create an adequate fluoroscopic image.



a. Active ROI 11.5 fps | b. Full field 1 fps | c. Blended image 12.5 fps

Figure 1. Coronary venogram. The blended image (c) is a composite of images (a) and (b) but to the operator appears as continuous fluoroscopy.

Methods and Materials

We assessed a system integrated into a fluoroscopic unit (Omega Medical Imaging, Sanford, FL) whereby imaging at a "normal" fluoro pulse rate (e.g. 12.5 frames per second) can be restricted to a tightly coned Region Of Interest (ROI) (Figure 1a). This ROI is identified in real time by an AI enabled automated tracking system which controls an ultrafast shutter between x-ray source and patient. The rest of the preselected manually collimated field is imaged less frequently (e.g. 1 fps) (Figure 1b). A composite image is created in real time by image blending software (figure 1c).

Preclinical

Air Kerma (radiation intensity) was measured using a Radcal Radiation Monitor during 20 second bursts of fluoroscopy on 20 and 30 cm thick phantoms.

Image quality assessment using a Leeds Test Object LTD, X-Ray test object TOR 18FG recorded resolution of 2.24 line pair/mm in both ROI and background regions.

Clinical

The first clinical study was on endoscopic guided fluoroscopic procedures[1]. To identify the ROI a convolutional neural network (CNN) was trained on 9,201 images and tested on 1,277 images.

One hundred consecutive patients were alternately assigned to fluoroscopy guided endoscopic procedures utilizing either conventional or AI equipped fluoroscopy (Fig 2). Radiation dose to the patient (Dose Area Product) and scatter were measured by identical means for both systems.

Results

Preclinical

Phantom Thickness	ROI imaging Rate	Whole FOV Imaging Rate	Predicted Dose Reduction	Measured Dose Reduction
20 cm	12.5 fps	1 fps	92%	84%
	12.5 fps	2 fps	84%	76%
30 cm	12.5 fps	1 fps	92%	83%
	12.5 fps	2 fps	84%	76%

Clinical

There were no significant differences in demographics, BMI, procedure type, or procedural or fluoroscopy time between the two groups

	Conventional Fluoroscopy	AI enabled Fluoroscopy	Dose Reduction
Patient Dose Median Range	5708 mGy/m^2 473 - 22017	2178 mGy/m^2 4792 - 24969	61.8% (p=0.001)
Cumulative scatter dose	0.69 mSv	0.28 mSv	59.4%

ROI was correctly identified by the auto processor in 48 / 50 patients; manual ROI control was successful in the other two. No difference in fluoroscopic image quality was observed.

Conclusions

Automated dynamic coning to a region of interest identified by artificial intelligence results in a significant decrease in radiation output while maintaining image quality. In the first clinical application significant dose reduction to patient and staff was confirmed without modification of procedural performance or staff behaviour.

Initial evaluation was on endoscopic procedures as FDA approval was received first. There is now approval for use in cardiac EP procedures and assessment is in process.

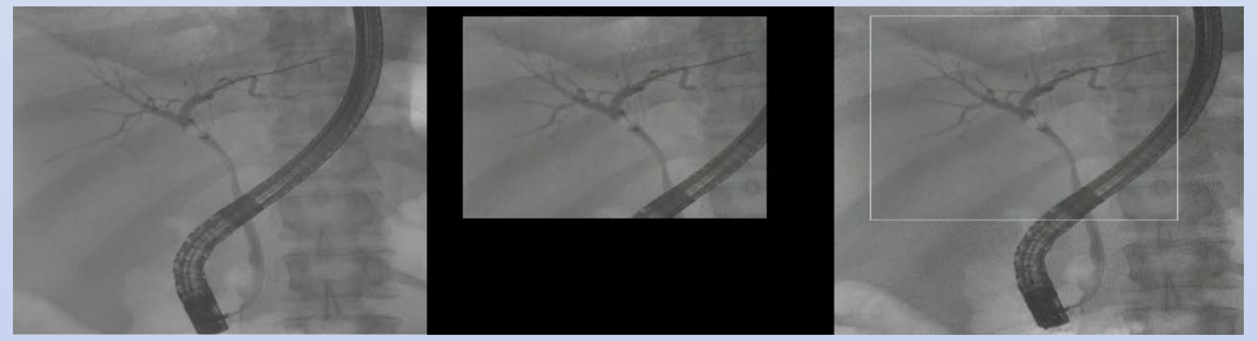


Figure 2. Endoscopic / fluoroscopic guided stone removal using AI enabled fluoroscopy

References

1. Bang JY, Hough M, Hawes RH, Varadarajulu S. Use of artificial intelligence to reduce radiation exposure at fluoroscopy-guided endoscopic procedures. Accepted for publication.

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