Assessment of Image Quality and Dose Reduction via Grid Elimination using Statistical Pixel Angiography over Digital Subtraction Angiography in Interventional Radiology

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INTRODUCTION

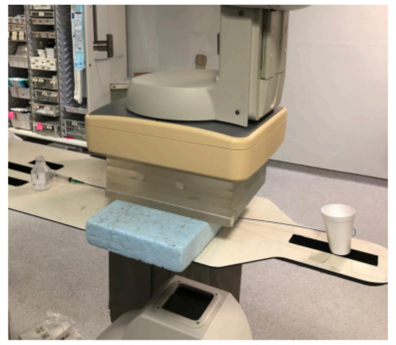
Digital subtraction angiography (DSA) is the current gold standard for angiography in interventional radiology (IR). DSA is susceptible to poor contrast resolution in large anatomical areas due to high scatter fields, thus DSA typically requires the use of grids. These grids are excellent at cleaning up scatter, but the reduced fluence to the image receptor causes the automatic exposure rate control (AERC) system to increase the x-ray output. These AERC systems are typically set by the manufacturer, and the use of grids can lead to Bucky factors of about 5. This output compensation can result in dangerously high peak skin doses to the patient, especially during complicated IR procedures.

AIM

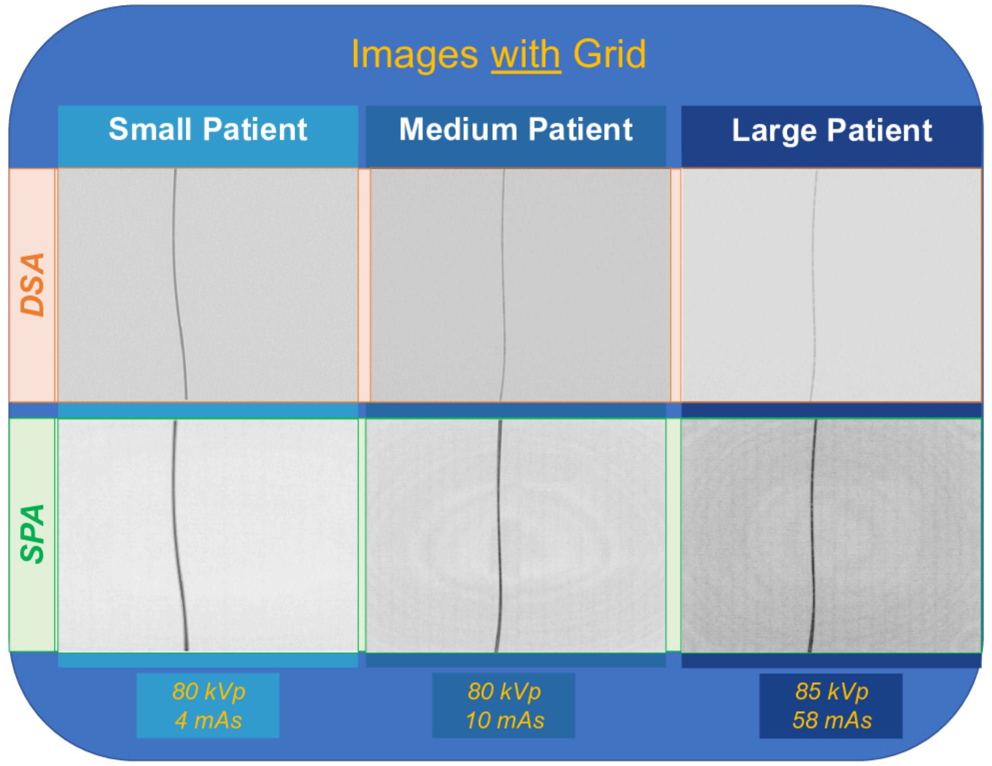
Previous studies have demonstrated the improved contrast of statistical pixel angiography (SPA) over DSA[1]. The SPA algorithm expands upon the principles of kinetic imaging[2] by applying multiple statistical analyses across the entire series of fluorographic images to enhance contrast and improve overall image quality. The improvements in using SPA over DSA can be leveraged to eliminate the use of grids, and thus allow the AERC to reduce the x-ray output. The present investigation consists of a controlled, phantom experiment to evaluate image quality and dose reduction in eliminating the grid for patients of various sizes.

METHOD

A phantom experiment was conducted with a Philips Allura fluoroscope to simulate contrast flowing through an artery. Varying thicknesses of acrylic were used to simulate three patient diameter sizes: small (18 cm), average (24 cm), and large (35 cm). The acrylic was stacked over a 1.8 mm diameter catheter, which served as a surrogate for an abdominal artery. Omnipaque contrast was injected into the catheter, and fluorographic images were acquired with and without the grid. The DSA images were summed to generate single sum-DSA images for reference comparisons. SPA images were then generated from the un-subtracted images. Contrast-to-Noise Ratios (CNRs) were calculated by analyzing regions of interest across the catheter in both sets of images, and ratios of SPA-to-DSA CNR (RCs) were reported.



RESULTS



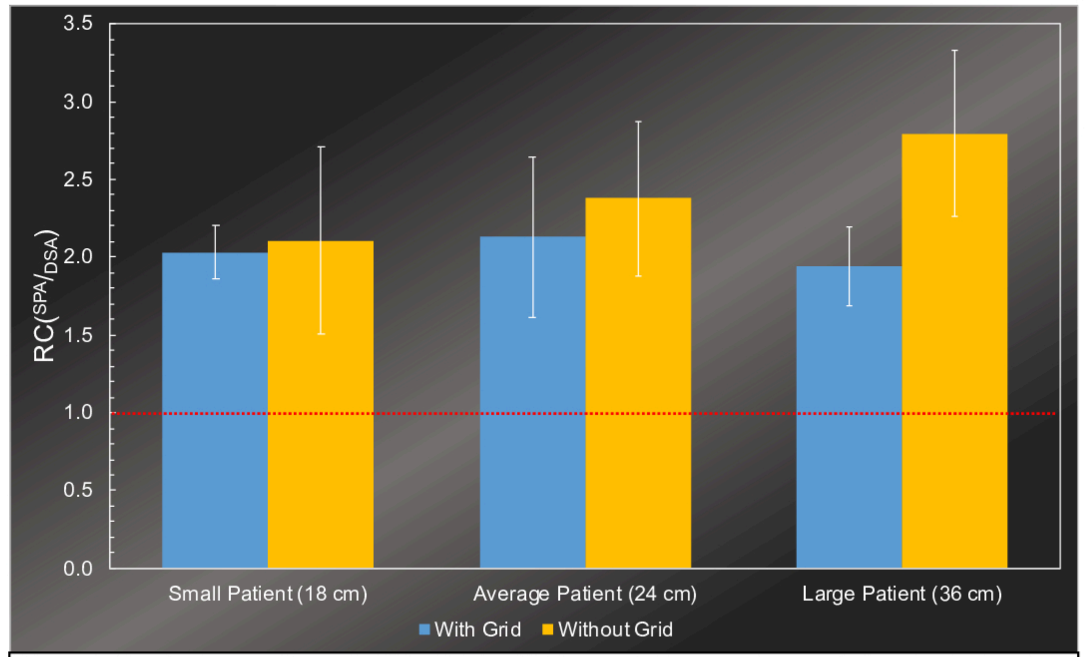
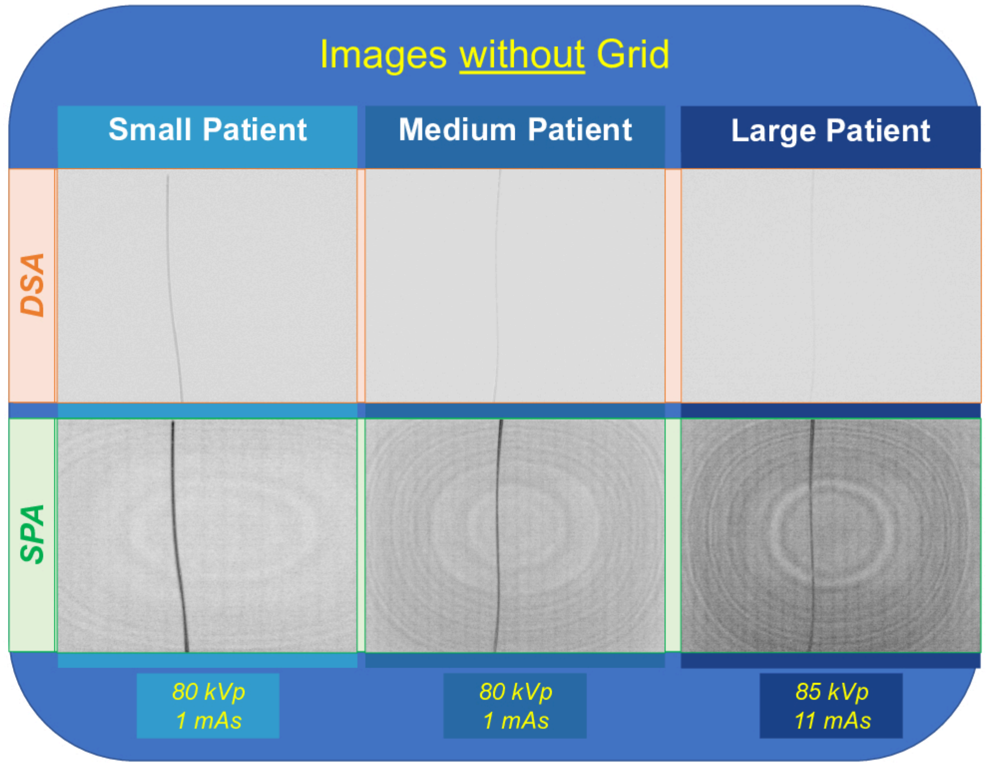


Figure 1. Results showing Ratio-of-CNRs (RC) for SPA to sum-DSA images taken with (blue) and without (yellow) the grid. Equal image contrast is indicated by the red line (1.0). On average, SPA has a two-fold increase in contrast over DSA.



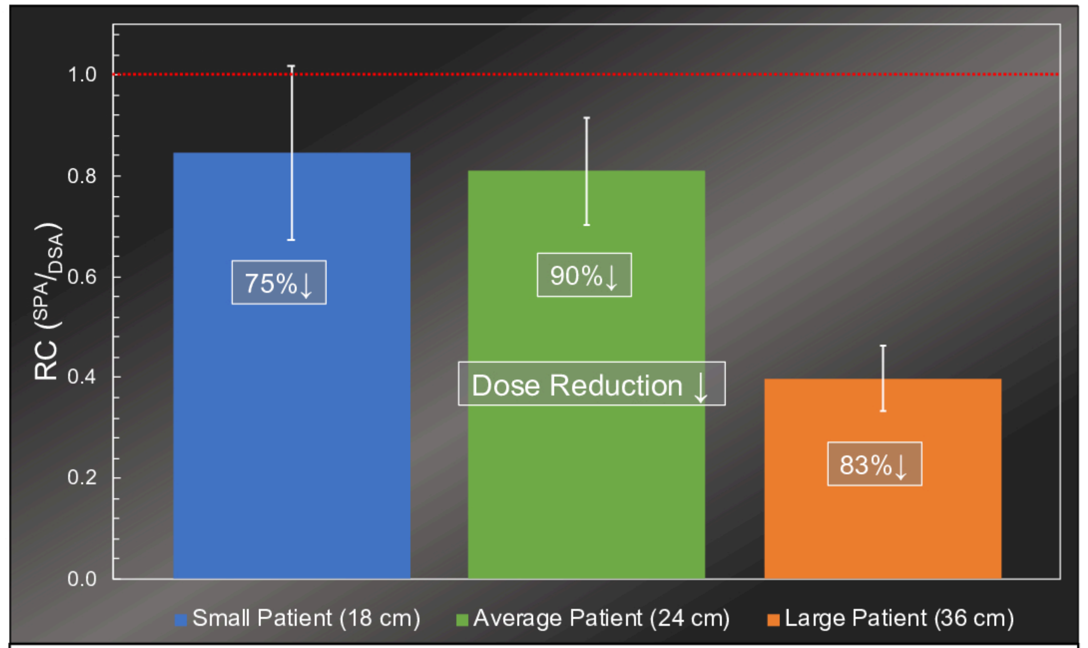


Figure 2. Results showing Ratio-of-CNRs (RC) for SPA images without the grid to DSA images with the grid. Equal image contrast is indicated by the red line (1.0). Comparable CNR is achieved for the small and medium sized patients, about 80%, and with a significant dose reduction for all cases. Although SPA without the grid was not able to achieve equal CNR as DSA with the grid, these results are for an AERC system that has not been optimized for the new algorithm.

CONCLUSIONS

The SPA algorithm resulted in significantly improved CNRs over the DSA images. The average RC($^{SPA}/_{DSA}$) for the images acquired with and without the grid was 2.03 and 2.42, respectively (Figure 1).

The SPA images without the grid were able to achieve up to 85% of the CNR of the DSA images with the grid for a small sized patient and 81% for a medium sized patient. This resulted in a dose reduction of 75% and 90%, respectively, without any optimization of the AERC (Figure 2).

SPA images can generate over twice the CNR of DSA images. The SPA algorithm in conjunction with grid elimination can produce comparable image quality, with a significant reduction in radiation output. Further optimization of the AERC system is necessary to achieve equal image quality as DSA to implement the SPA algorithm without the use of grids.

The improvements in SPA image quality over DSA can be leveraged to eliminate the use of grids in interventional radiology, possibly for small or pediatric patients. This can reduce peak skin doses and prevent potential skin burns for extended procedures. Furthermore, a reduction in radiation output benefits not just the patient, but also the radiologists and staff in the room.

ACKNOWLEDGEMENTS

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REFERENCES

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[2] K. Szigeti, D. Máthé and S. Osváth, "Motion Based X-Ray Imaging Modality," in IEEE Transactions on Medical Imaging, vol. 33, no. 10, pp. 2031-2038, Oct. 2014.

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