

Anti-Scatter Grid Utilization in Pediatric Diagnostic Fluoroscopy

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ABSTRACT

Purpose: Pediatric fluoroscopy requires careful optimization of radiation dose while maintaining diagnostic image quality. Anti-scatter grids improve contrast but can substantially increase patient dose, particularly in small patients where scatter contribution is limited. This study investigates patient thickness conditions where grid removal may reduce radiation dose without compromising image quality.

Methods: A Leeds Test Object 10 phantom was imaged on a Siemens Luminos Agile Max fluoroscopy system using a pediatric voiding cystourethrogram protocol. Acrylic thicknesses from 0–11 inches were evaluated with and without the anti-scatter grid using two fluoroscopy technique curves: a default pediatric curve and a modified pediatric curve that prioritizes low contrast resolution. Contrast-to-noise ratios (CNR) and Air kerma rates (AKR) measured and used to calculate AKR-normalized CNR (CNR_n).

Results: The anti-scatter grid improved CNR across nearly all acrylic thicknesses but increased AKR by 2.2× and 2.6× for the default and modified curves, respectively. When normalized by AKR, a crossover point was observed at approximately 4–4.5 inches of acrylic, below which CNR_n was improved without the anti-scatter grid. This threshold was consistent across both fluoroscopy technique curves despite differences in image acquisition parameters.

Conclusion: A patient thickness threshold exists where removal of the anti-scatter grid may reduce radiation dose while maintaining image quality in pediatric fluoroscopy. These results provide a quantitative basis for developing patient-size-based grid utilization recommendations.

INTRODUCTION

Anti-scatter grids improve image contrast by reducing scattered radiation but can increase patient dose due to increased exposure requirements. In pediatric patients, where scatter production is minimal, the benefit of grid use may be limited. Current grid utilization practices are often based on general recommendations rather than quantitative evaluations performed on the basis of patient size. A quantitative evaluation of image quality relative to radiation dose may help identify patient thickness conditions where grid use provides the greatest benefit.

METHODS AND MATERIALS

An image quality phantom (Leeds Test Object 10) was imaged on a flat-panel based general fluoroscopy system (Siemens Luminos Agile Max). The phantom was elevated 2 cm above the table to allow placement of a dosimeter underneath for entrance Air Kerma Rate (AKR) measurements. Radiolucent supports positioned acrylic blocks 7 cm above the table (Figure 1). Using a Pediatric Voiding Cystourethrogram protocol and the lowest automatic dose mode, 10-frame fluoroscopy exposures and AKR measurements were taken with acrylic thicknesses ranging 0–11 inches at 1-inch intervals with and without the anti-scatter grid. Using ImageJ, regions of interest (ROIs) were drawn on the stored fluoroscopy loop (Figure 2) and used to calculate a contrast-to-noise-ratio (CNR) and an AKR normalized CNR (CNR_n).

Two fluoroscopy technique curves were evaluated: Curve A, the default pediatric voiding cystourethrogram technique curve, and Curve B, a modified technique curve previously developed to improve image contrast in pediatric patients.

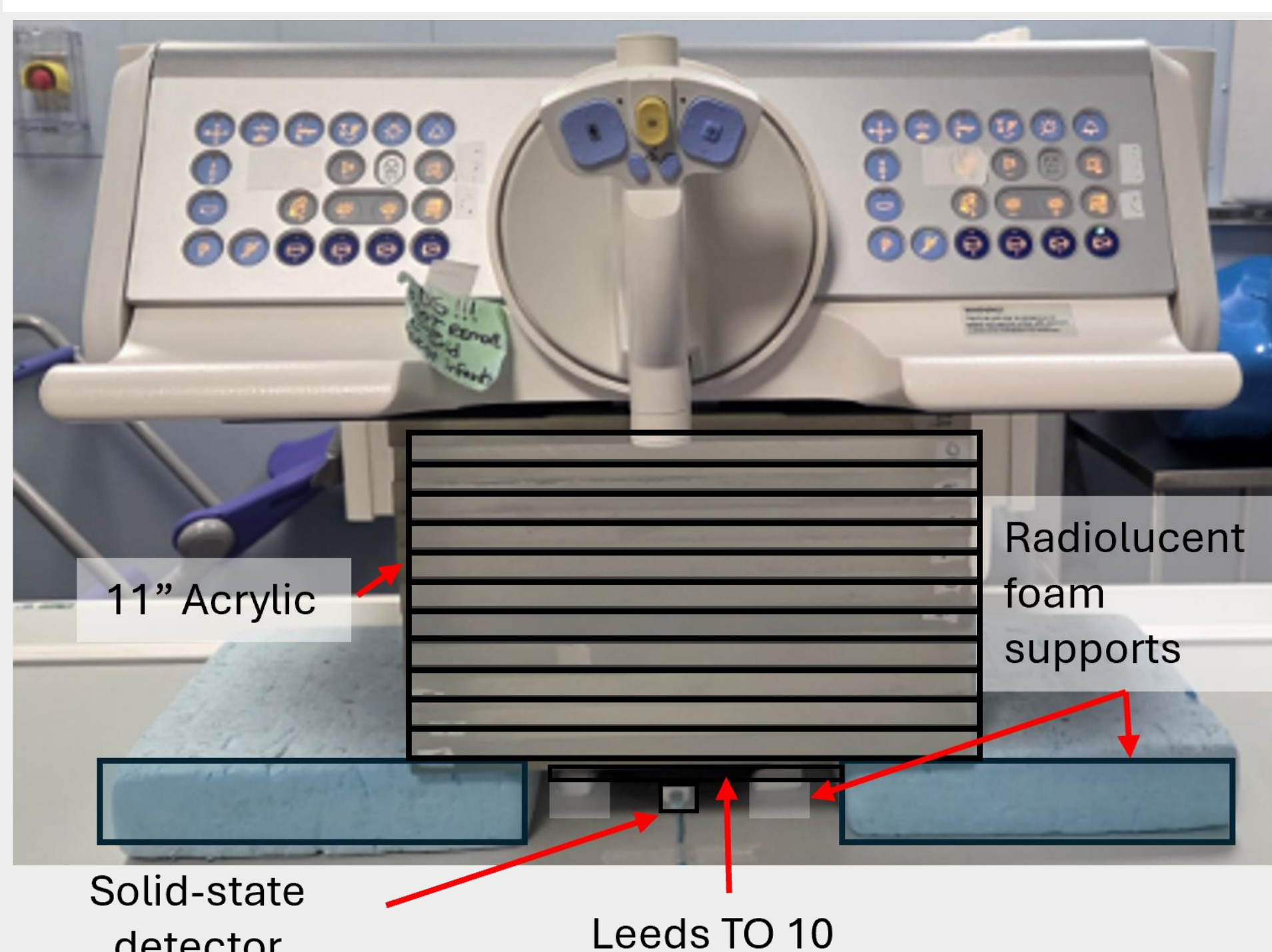


Figure 1. Experimental setup with 11 inches of acrylic positioned above the phantom to simulate patient attenuation.

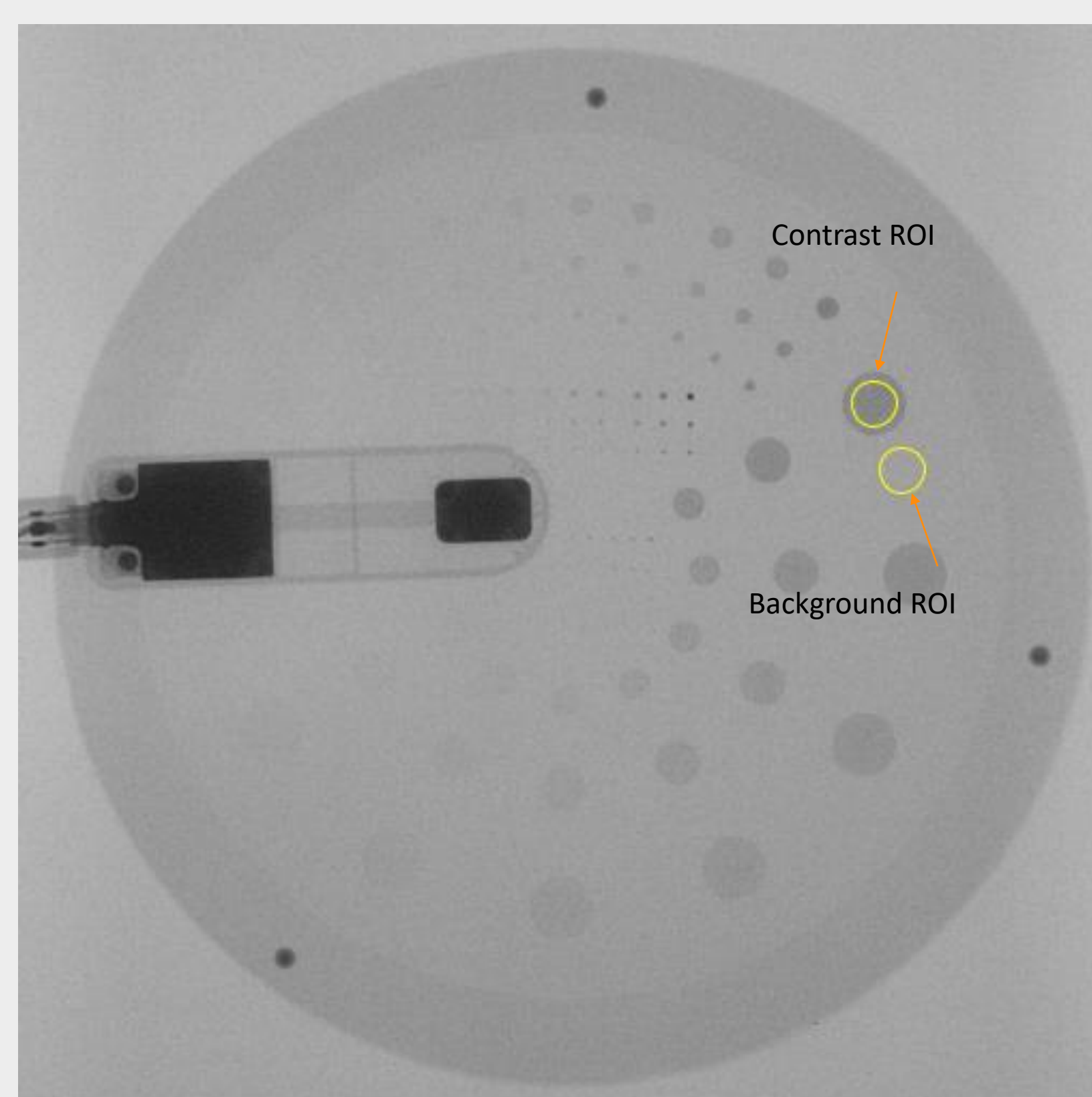


Figure 2. Fluoroscopy image showing the solid-state detector, image quality phantom, and example ROIs.

RESULTS

CNR was higher with the anti-scatter grid at all acrylic thicknesses except 0–1 in., where scatter was minimal (Figure 3). This improvement came at the cost of increased radiation dose, with AKR increasing by a factor of 2.2 for Curve A and 2.6 for Curve B when the grid was used (Figure 4). After normalizing CNR by AKR (CNR_n), a crossover point was observed at approximately 4.0–4.5 in. of acrylic, below which image quality per unit dose was greater without the anti-scatter grid (Figure 5).

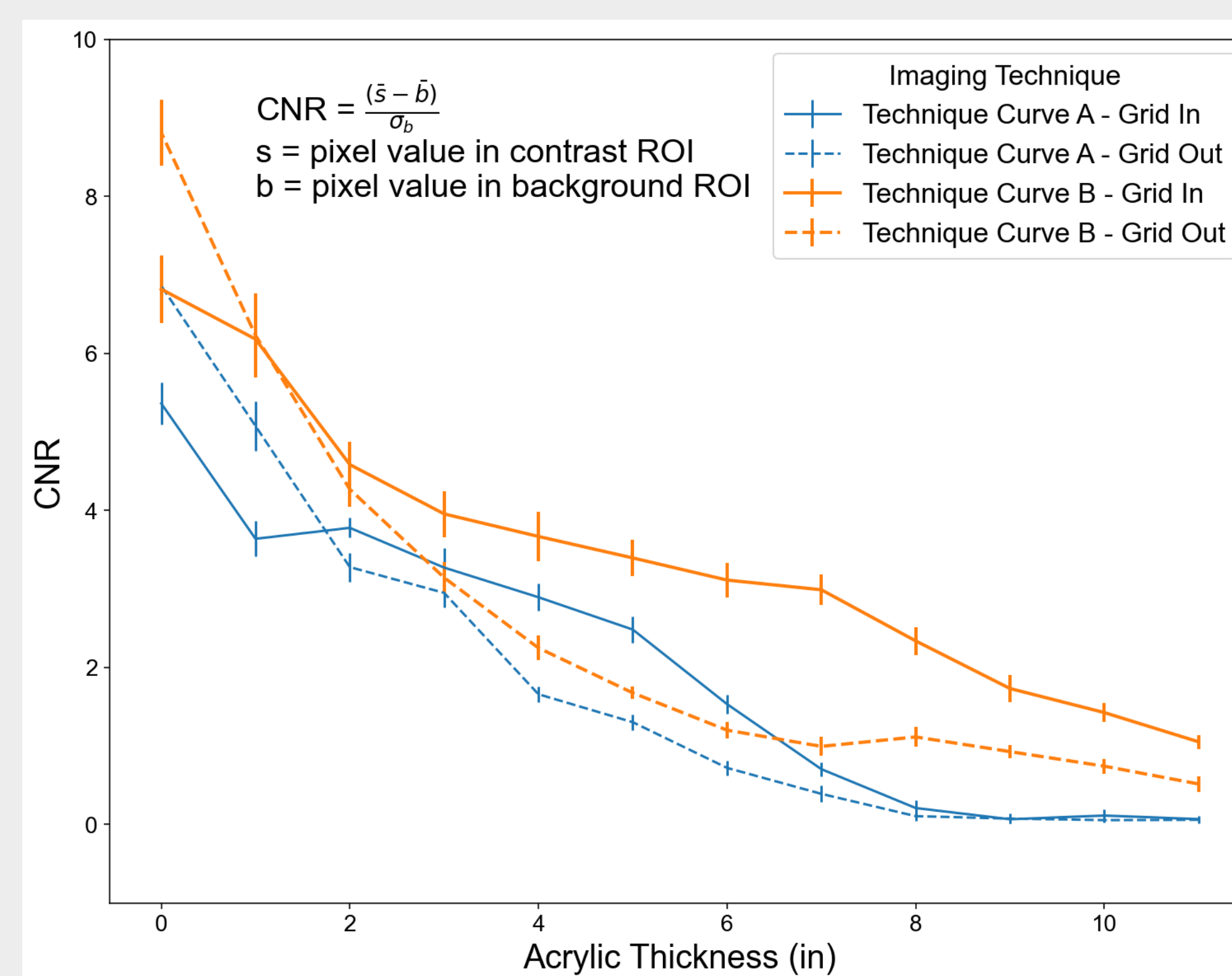


Figure 3. Contrast-to-noise ratio (CNR) as a function of acrylic thickness for two fluoroscopy technique curves with the anti-scatter grid in and out. Mean ± standard deviation across 10 frames are shown.

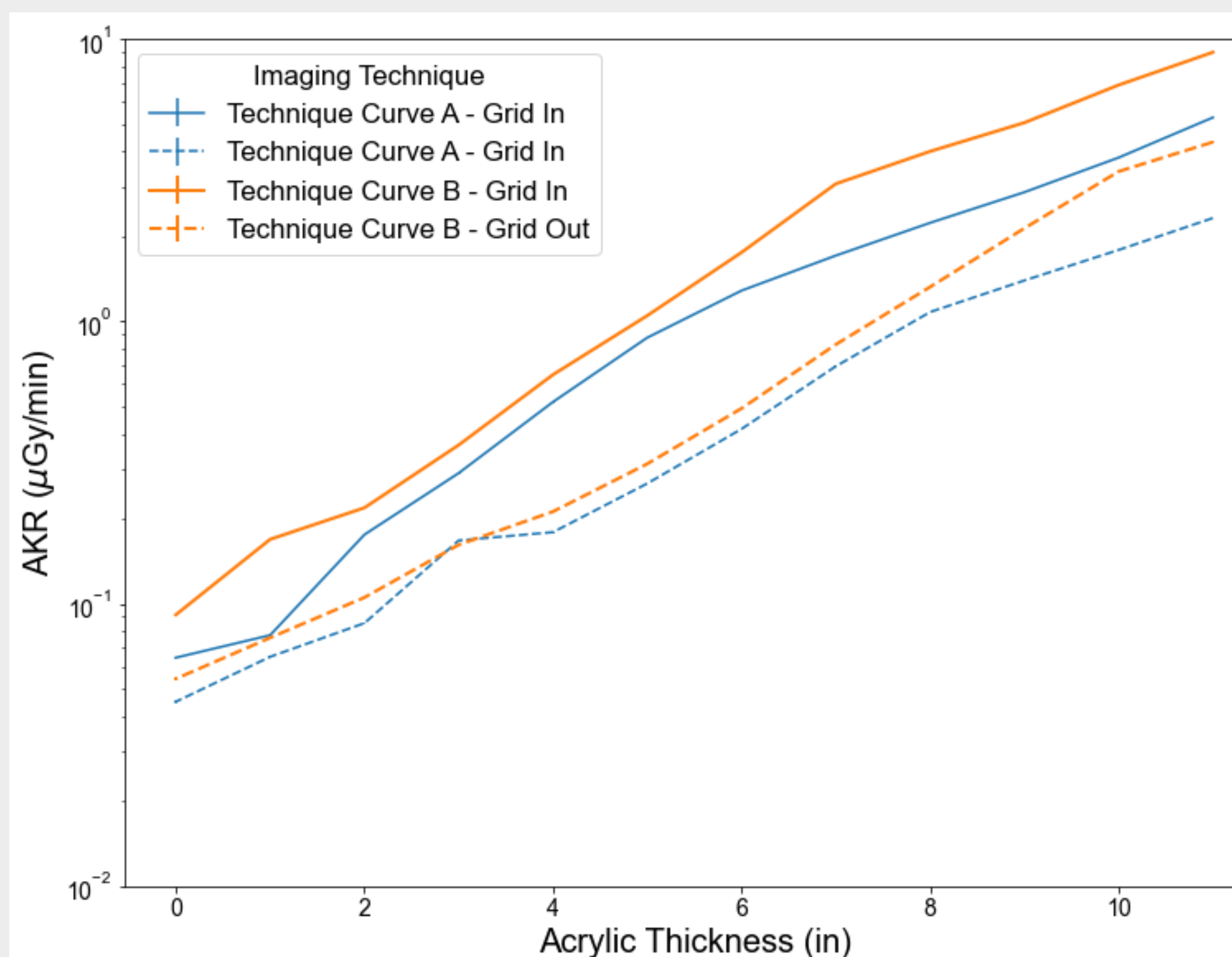


Figure 4. Air kerma rate (AKR) as a function of acrylic thickness for the four imaging techniques. Mean ± standard deviation across three exposures are shown.

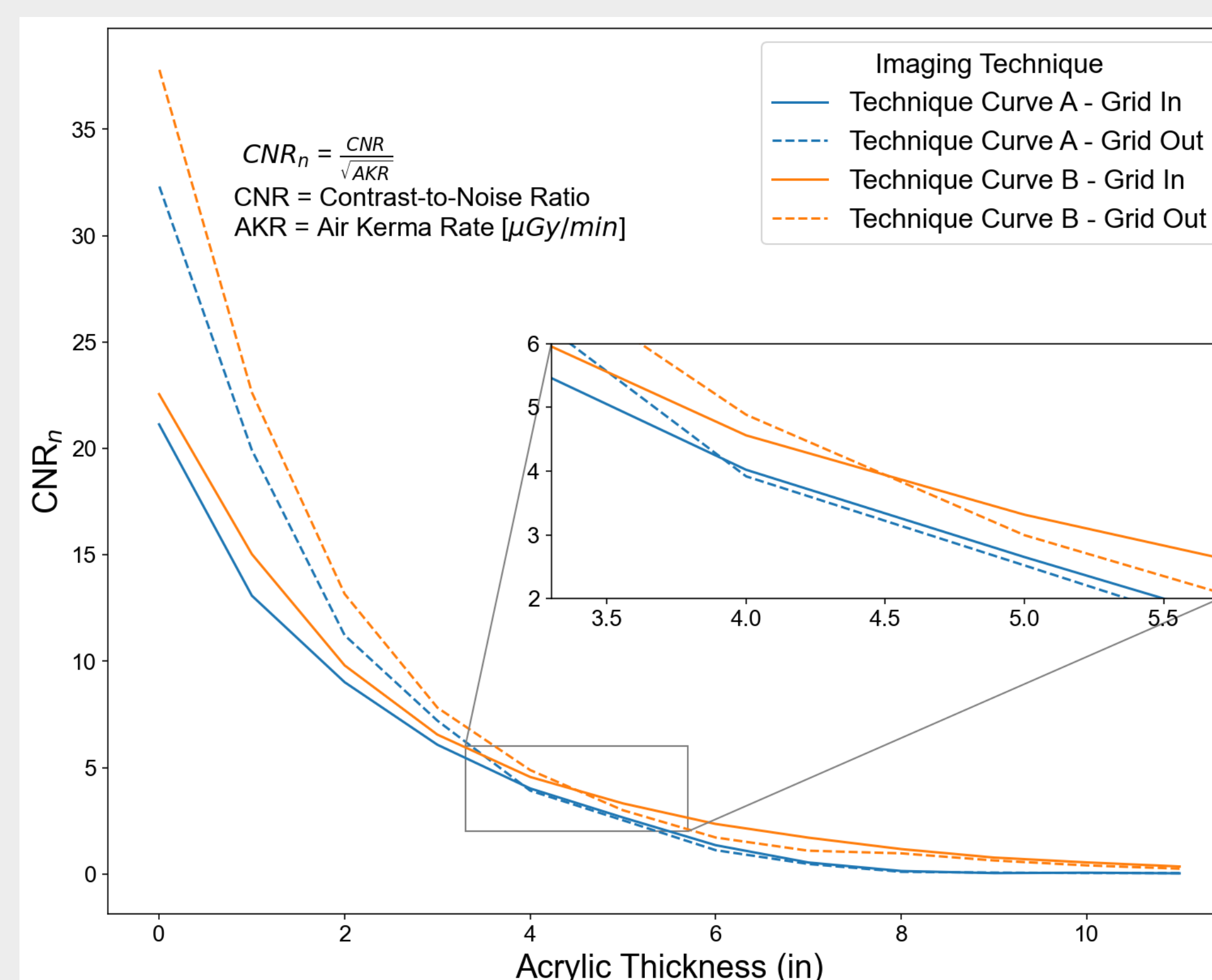


Figure 5. CNR_n as a function of acrylic thickness. Below approximately 4–4.5 inches of acrylic, CNR_n is improved without the anti-scatter grid.

DISCUSSION

The crossover in CNR_n identifies a patient thickness below which removing the anti-scatter grid provides superior image quality per unit dose. At thicknesses greater than this, image quality is comparable. This suggests that the anti-scatter grid can be safely removed for smaller pediatric patients without compromising clinically relevant image quality, while substantially reducing radiation dose. This crossover thickness was observed for both fluoroscopy technique curves, despite the variability in their automatic exposure strategies (Figure 6). Curve B was specifically designed to preserve image contrast by preferentially increasing tube current before tube potential, yet both technique curves demonstrated a similar crossover thickness (~4–4.5 in. acrylic). This agreement suggests that the observed threshold is not solely driven by differences in kV selection. Future work will establish patient-equivalent thickness thresholds for common pediatric fluoroscopic examinations to develop exam-specific grid utilization recommendations. Additional studies will evaluate image intensifier-based fluoroscopy systems, assess the impact of iodinated contrast (routinely used during pediatric diagnostic fluoroscopy), and validate these findings through a multi-institutional collaboration. Translation into clinical practice will involve evaluation of patient-size-based grid utilization recommendations while monitoring image quality and diagnostic confidence.

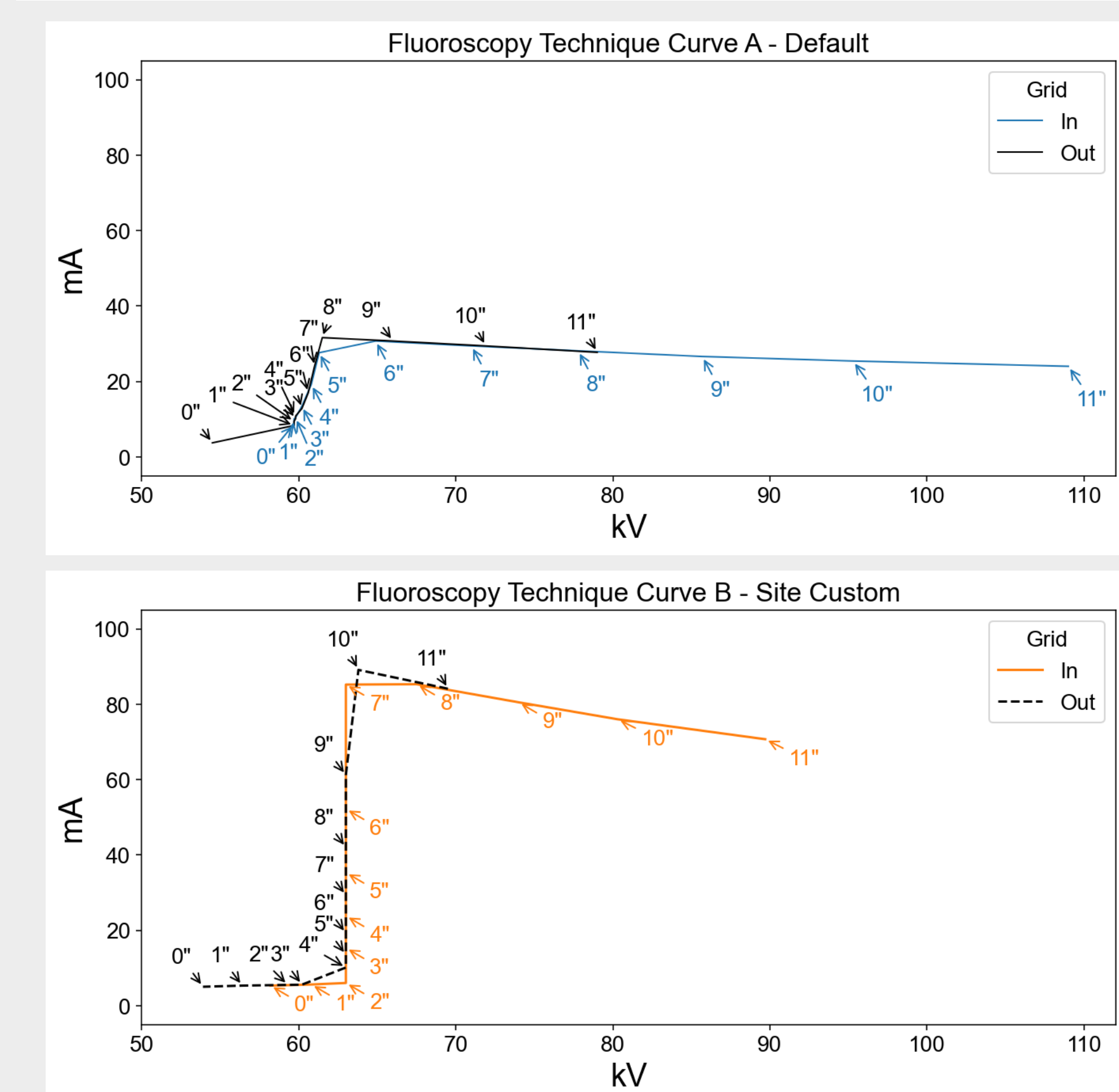


Figure 6. Fluoroscopy technique curves for the default pediatric curve (top) and custom contrast-focused curve (bottom).

CONCLUSIONS

This study demonstrates that a patient thickness threshold exists below which removal of the anti-scatter grid can reduce radiation dose while maintaining image quality in pediatric diagnostic fluoroscopy. Using AKR-normalized CNR, a crossover point was identified at approximately 4–4.5 inches of acrylic, indicating improved image quality per unit dose without the grid for smaller patient sizes. This threshold was consistent across two fluoroscopy technique curves with different automatic exposure strategies, suggesting the finding is robust across technique approaches.

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