Optimizing chest radiograph collimation in the neonatal intensive care unit: a departmental quality control initiative

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BACKGROUND

A primary means of reducing dose during common radiographic procedures is to limit the radiation field via collimation. An international guideline has been issued detailing the appearance of an ideal chest radiograph (CXR)[1,2,3,4] (Figure 1). Studies detailing methods by which to achieve that ideal through collimation in the neonatal intensive care unit (NICU) are scarce.

PURPOSE

This study implements a practical collimation technique utilizing external body landmarks to produce NICU CXR with more consistent and appropriate collimation.

METHODS

- The study includes164 NICU CXR from 2014-2016. CXR for new line or tube placement were excluded as they require a larger field of view.
- Two radiographers were trained in the collimation technique initially to confirm the technique's clinical feasibility with 8 CXR. All radiographers were then trained in the technique.
- The study includes 51 CXR obtained prior to training, 54 CXR one month after training, and 51 CXR one year after training.
- Studies were reviewed by a radiology resident (R3) and two pediatric radiologists.
- Edges of each chest radiograph were individually graded as optimal (3), acceptable (2), or unacceptable (1). (Figure 2)
- Top edge: 3 = below the midpoint of the C2-3 intervertebral disc space, 2 = C2-3 to the inferior margin of the bony orbit, and 1 = any inclusion of the bony orbit.
- Bottom edge: 3 = above the midpoint of the L2-3 intervertebral disc space, 2 = L2-3 to L5-S1, and 1 = below L5-S1.
- Objective anatomic landmarks were difficult to define for the lateral edges, thus the reviewers rated them subjectively on the same 3 point scale.
- If a margin excluded lung, it received a 1.
- CXR margin ratings prior to radiographer training were compared to ratings after training utilizing Kruskal-Wallis, Wilcoxon rank (adjusting for multiple comparison by Bonferroni's method), and Fisher's exact tests.

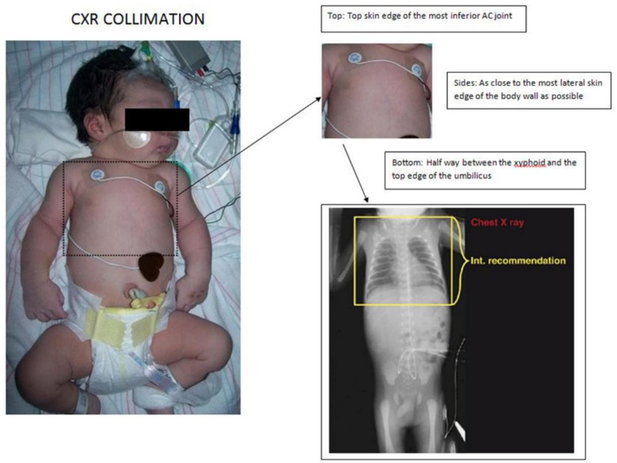

FIGURE 1: External collimation landmarks

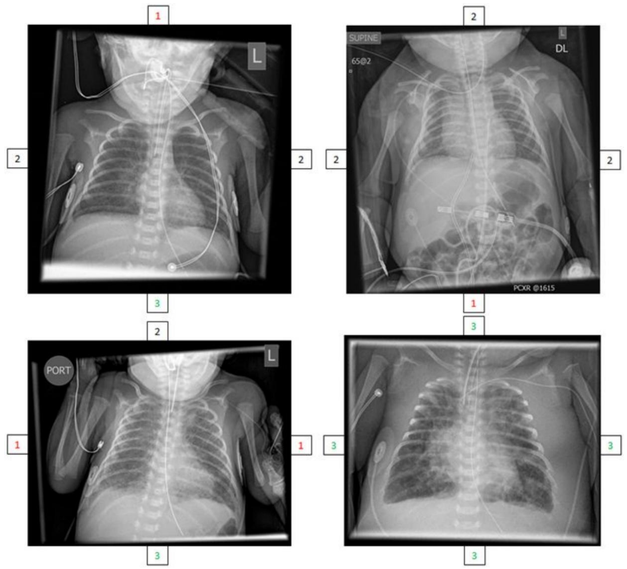

FIGURE 2: Collimation edge scoring. 3 = optimal, 2 = acceptable, 1 = unacceptable.

RESULTS

A statistically significant improvement was observed in top edge ratings from pre- to immediately post-training (mean 2.29 to 2.65, p<0.0167). While top edge ratings remained improved from pre-training to one year post-training (mean 2.29 to 2.59), the improvement was no longer significant. Bottom edge ratings progressively improved from pre-training to one year post-training (mean 2.39, 2.43, 2.59), however, the improvement was not significant. (Tables 1 and 2). While variably improved from pre- to immediately post-training, right and left edge ratings had returned to near pre-training levels by one year post-training.

DISCUSSION

Initial review of radiographic practices in the University of Minnesota Masonic Children's Hospital NICU revealed some effective methods were already being employed by radiographers to reduce dose. This included the absence of grid use, the absence of post-acquisition image cropping (which falsely decreases the apparent amount of radiated tissue), and knowledge of the mAs and kVp settings and exposure indices appropriate for NICU patients. There was, however, opportunity for improvement in collimation, as excess body tissues were routinely being included in standard CXR.

Appropriate CXR collimation with light beam guidance minimizes the radiation dose a patient receives by excluding as much of the non-lung body structures as possible. While pathology can exist and be excluded with very tight collimation standards, one study suggested that significant findings of any sort would be revealed in the mid to upper abdomen in less than 3% of pediatric patients were it to be included in a standard ordered CXR.[5]

In capturing quality images, radiographers are responsible for adhering to the ALARA (as low as reasonably acceptable) principle to minimize radiation dose, which requires a familiarity with a range of complex variables gained through effective training and clinical experience. Tight collimation limits unnecessary direct radiation dose and minimizes dose related to scatter from excess tissues included in the radiation field (scatter also deceases image contrast).[6]

The small size of patients in the NICU makes collimating effectively uniquely difficult. In this study the difference between a 3 rating and a 1 rating could represent a difference in collimation of less than 2-3 cm. The International Atomic Energy Agency recommends the tolerance away from optimal collimation in the neonatal population should be 1 cm or less.[6] The relative size variation of patients in the NICU was not controlled for in our study. Despite this limitation, using our collimation technique based on body landmarks has lead to NICU CXR which are more consistently similar to the international standard. Given the return to baseline for lateral edge scores by one year post-training and slight regression in top edge scores immediately post-training to one year post-training, re-training of technologists will be required to maintain our collimation standards over time.

Variable	Category	Before (N=51)	2015 (N=54)	2016 (N=51)	P-value
Top	n	51	54	51	0.0099
	Median	2.00	3.00	3.00	
	Mean (SD)	2.29 (0.67)	2.65 (0.52)	2.59 (0.54)	
	(Min, Max)	(1.00, 3.00)	(1.00, 3.00)	(1.00, 3.00)	
Top (cat)	1	6 (11.76)	1 (1.85)	1 (1.96)	0.0277
	2	24 (47.06)	17 (31.48)	19 (37.25)	
	3	21 (41.18)	36 (66.67)	31 (60.78)	
Bottom	n	51	54	51	0.1868
	Median	2.00	2.00	3.00	
	Mean (SD)	2.39 (0.57)	2.43 (0.57)	2.59 (0.50)	
	(Min, Max)	(1.00, 3.00)	(1.00, 3.00)	(2.00, 3.00)	
Bottom (cat)	1	2 (3.92)	2 (3.70)	0	0.3486
	2	27 (52.94)	27 (50.00)	21 (41.18)	
	3	22 (43.14)	25 (46.30)	30 (58.82)	

Table 1: Top and bottom edge statistical summary with P-values utilizing Kruskal-Wallis test for continuous scale and Fisher's exact test for categorical (P-value <0.05 in yellow).

	Before vs. 2015	Before vs. 2016	2015 vs. 2016
Top	0.0056	0.0265	0.5437
Top (cat)	0.0132	0.0428	0.7695

Table 2: Pairwise comparison P-values for top edge ratings utilizing Wilcoxon rank test for continuous scale and Fisher's exact test for categorical (P-value <0.0167 in yellow).

CONCLUSION

Implementation of a CXR collimation technique utilizing external landmarks resulted in improvement in top and bottom edge collimation of NICU CXR and in CXR that more consistently approached the international standard. Improvement in lateral edge collimation diminished over time, suggesting repeat radiographer training and individual performance feedback are necessary.

LITERATURE CITED

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