Letter to the Editor

Charles E. Willis

Dear Dr. Honeyman-Buck,

I was excited to read the article by John Aldrich et al. entitled "Optimization of Dose and Image Quality for Computed Radiography and Digital Radiography" in the June 2006 issue of *Journal of Digital Imaging*. Dr. Aldrich and his coauthors are to be congratulated for sharing their long and arduous work in optimizing digital projection imaging in their hospital.

However, the article omits key information that prevents others from being able to reproduce the work independently and limits reasonable conclusions that can be drawn from the results presented. My concerns are listed below, without any particular order of precedence.

Many relevant literature references are absent. For example, a classic reference on the adjustment of automatic exposure control (AEC) systems for computed radiography (CR)¹ would seem at least worthy of mention. Also missing are references to literature about the meaning of the CR exposure indicator (S number) and the phenomenon of exposure factor creep in CR.^{2,3}

While there is a statement that "x-ray units were calibrated every 6 months," there is no mention of how, when, or whether CR and digital radiography (DR) systems were calibrated for gain and uniformity. This calibration is important in terms of both image quality and dose.

For the Rando phantom CR images for which the S number was reported, there was no mention of the corresponding latitude (L) values. Chotas and Ravin⁴ have shown that inattention to the L value can lead to unsatisfactory images. In automatic exposure data recognizer mode, L values that are out of range are accompanied by S numbers that are not representative of receptor exposure.

A key omission in the manuscript is the lack of a report of the actual parameter values for CR and DR for the "smoother" processing algorithms. These algorithms seem to have been critical in rendering digital images acquired at lower doses appropriately for interpretation. With respect to the CR images, the authors state that "In 60% of the cases, the lower-dose image with the new algorithm was preferred." Were the higher-dose images also rendered with the new algorithm for comparison to the lower-dose image? This comparison is important in sorting out whether the preference was related to the dose reduction or the change in image processing. Although the Philips DR system calculates a derived exposure index (EI) for every exposure, there was no report of any EI values from the DR exams. Instead, the authors chose to use the dose-area product value that is reported for each exposure. Other text suggests this might be the kerma-area product rather than the dose-area product. I wonder whether this value is an actual "meter reading" as indicated in the manuscript or a value calculated by the DR system based on the calibrated output at the kilovolt peak and milliampere-seconds delivered for the exposure. The numerical value of the backscatter factor used to convert air kerma into entrance surface air kerma is not reported,

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although the authors mention that it was dependent on field size and kilovolt peak. The actual value used varies among practitioners.

The criticism of the Nationwide Evaluation of X-ray Trends (NEXT) chest phantom found on pages 130 to 131 and the discussion of Table 4 (later referred to as Table 7) is confusing to me. The LucAl phantom is designed to be a patient-equivalent phantom for the lungs, not the mediastinum.⁵ It is designed for a posteroanterior view where the exposure factor is conventionally controlled by the left and right ion chambers (photocells), not the center chamber, which is used to control exposure factor for the lateral view. Each of these cells is usually set up to deliver a particular exposure to the receptor, irrespective of the anatomy that is projected onto it. The exposure level can be modified by a service engineer. The change in exposure with density settings is likewise configurable. It is unclear why the CR chest exams were set up using the center cell, except perhaps to deliver the additional exposure desired. Why would all three cells be used on the DR? With three cells activated, the center cell is superfluous. The AEC should shut off when any one of the cells reaches its calibrated exposure value, likely one of the two lung cells. The “+2 density setting” is a common approach for coaxing the x-ray generator into delivering more exposure for CR, but this is the first report I have seen of using the center cell. Certainly the mediastinum and spine will attenuate the beam more in the posteroanterior view than the lungs will, so the exposure of five times the screen-film exposure using the lung cells is not surprising. Some x-ray control systems allow the operator to select different image receptors to accommodate the use of different speed class screen-film systems, such as the 300-speed and 400-speed system that the authors use. This seems a better alternative than changing the active AEC cell, which is designed for the specific anatomy and view. I am also concerned about the description of diagnostic reference levels as “target values.” Although the discussion on page 130 ameliorates my concern to some extent, the reference level is supposed to be an “action limit.” Also, it is based on the statistics of current practice, whether right or wrong. The American Association of Physicists in Medicine reference

levels (reference 13 in their article) are based on measurements with the LucAl phantom during the NEXT surveys.

Slightly higher kilovolt peak values used for DR will naturally decrease the exposure for these studies. CR is less sensitive to kilovolt peak changes than screen-film is, so I wonder why the DR techniques were not applied to the CR studies. While the authors’ efforts to reduce the dose are laudable, a better goal would be to manage the radiation dose so that the appropriate exposure is delivered to the receptor in order to produce an image that is adequate for the diagnostic task. What criteria were used to determine that “all examinations were of diagnostic quality”? As the authors note, this is difficult to establish objectively. Literature on CR and DR imaging characteristics suggests that, to reproduce the noise characteristics of screen-film receptors, exposures approximately equivalent to 200- and 500-speed classes, respectively, should be used.^{6,7} There is some evidence that prepatient filtration may reduce the necessary exposure by 25%,⁸ and certainly improvements in the conversion efficiency of the CR and DR receptors could reduce the exposure required as seen in structured phosphor⁹ and dual-sided reading of CR.¹⁰

In summary, the findings of Aldrich et al. are not that different from the experience of other clinical practitioners. Both CR and DR require more exposure than initially anticipated and modifications in the image processing delivered by manufacturers in order to produce images of acceptable diagnostic quality. More exposure is needed for CR than 350–400-speed-class screen-film systems. The same or slightly less exposure than 350–400-speed-class screen-film systems is needed for DR. Their report is valuable in documenting this to the community. I look forward to reports of further details of their methodology.

Respectfully submitted,

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