Optimizing Radiation Dose for Samsung GC85A

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Introduction

ALARA (As Low As Reasonably Achievable) is a radiation safety principle for minimizing radiation doses and releases of radioactive materials by employing all reasonable methods. The PI and research staff, with the support of the Radiation Safety Division (RSD), should ensure that the ALARA principle is being used in all lab operations. Samsung Medical Center (SMC), Seoul, South Korea is a state of the art hospital that is focused on providing the best care to its patients as well as lead cutting edge research in various fields of healthcare. With the installation of a premium X-ray system, GC85A, manufactured by Samsung Electronics, SMC is attempting to perform its X-ray imaging with utmost low radiation dose as possible while maintaining the best image quality. This white paper is a testimony to the experiments undertaken to successfully reduce radiation dose below current practice levels.

Methods

Dose reduction feasibility and low dose image quality evaluation was first performed using phantom (DIGRAD phantom) experiments. Chest protocol was chosen for optimization. Based on the results of the phantom experiments, adult and pediatric patients underwent x-ray examinations. Entrance Skin Dose (ESD) was used as a measure of dosage with varying values of copper filter, peak kilovoltage (KVp) and quantity of X-ray photons in milliamp seconds (mAs). Images acquired with normal routine dose were compared with the new reduced dose protocol.

1. Dose Metric
Dose measurement was performed using a dose meter (RaySafe Xi; Unfors; Billdal; Sweden) placed on a body surface. Entrance Surface Exposure (ESE) value was measured and recorded for analysis. The values obtained were compared with international and domestic DRL (diagnostic reference level)

2. Spectrum optimization
To set up appropriate exposure conditions for each body size, quantitative and qualitative evaluations were performed. Contrast-to-Noise-Ratio (CNR)[2] measured at varying kVp and mAs was used for quantitative evaluation. Four radiologists (more than 10 years experience) reviewed the images acquired on an anthropomorphic chest phantom to arrive at an acceptable dose level.

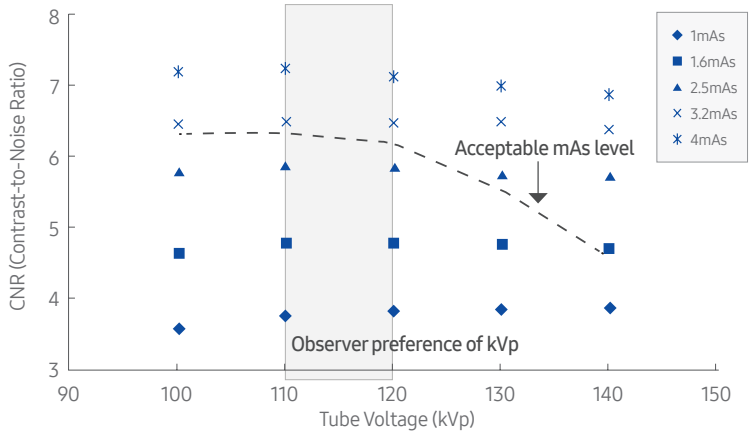

Figure 1. CNR and the preference of kVp for an adult Chest PA

Figure 1 shows the spectrum of CNR measured across increasing kVp at varying mAs for an adult. The plot of acceptable image quality is shown based on the evaluations by the radiologists. It is observed that the acceptable CNR value is higher for voltages less than 120 kVp compared to higher kVp's. The mAs requirement drops for voltages higher than 120 kVp. Similar spectrum plots were used to arrive at the optimal acquisition parameters for different patient sizes. The protocol details are explained below.

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3. Protocol and Patient Size
Five different chest protocols customized to suit baby, child, small size adults, medium size adults and large sized adults were created. The exposure conditions were set according to their respective age and weights. The complete list of acquisition parameters for each body size is shown in Table 1.

Table 1. Acquisition parameters of each body size for chest exposure

Protocol		Body size	weigh (kg)	filter	kVp	SID (cm)	grid
Chest	AP	Baby	10	0.1mmCu	55	110	X
Chest	PA	Child	30	0.1mmCu	100	180	O
Chest	PA	Small size adult	50	0.1mmCu	105	180	O
Chest	PA	Medium size adult	70	0.1mmCu	110	180	O
Chest	PA	Large size adult	90	0.1mmCu	120	180	O

(SID: source-to-image distance)

4. Low dose post-processing
The image acquired from low radiation dose increases noise compared to a normal dose so that the structure information of anatomy is blurred. In order to overcome this problem, a multi-resolution based denoising method for preserving the structural information is applied to improve post-processing in dose reduction situation.

5. Clinical evaluation
For clinical evaluation, the ESD values were decreased in steps by controlling the mAs under the optimal kVp and copper filter values identified above. The beginning value of the ESD was set to the currently used settings in routine practice at SMC. Image comparison was performed to evaluate the quality before and after optimization.

Evaluation

1. Phantom results
From phantom (DIGRAD) test, the measured CNR was compared with the ESD level for the exposure condition provided as a factory setting of GC85A. Figure 2 confirms the possibility of dose reduction of to 60% to maintain 100% dose rate CNR.

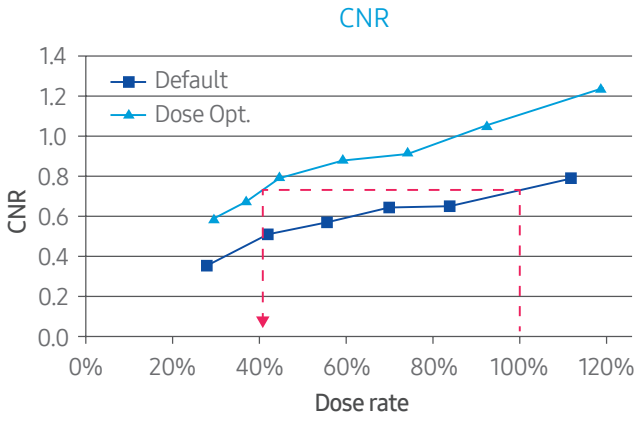

Figure 2. CNR for each dose rate in phantom

2. Clinical results
Clinical evaluation was performed between November 2015 to January 2016 at SMC by enrolling 79 patients. With acceptable image quality (LDI-3 phase), it can be observed that up to 40% reduction in dose rate for adult chest PA and 50% in adult chest AP can be achieved. For pediatric case a dose rate reduction of 40% for child chest PA and about 55% for child chest AP may be achieved.

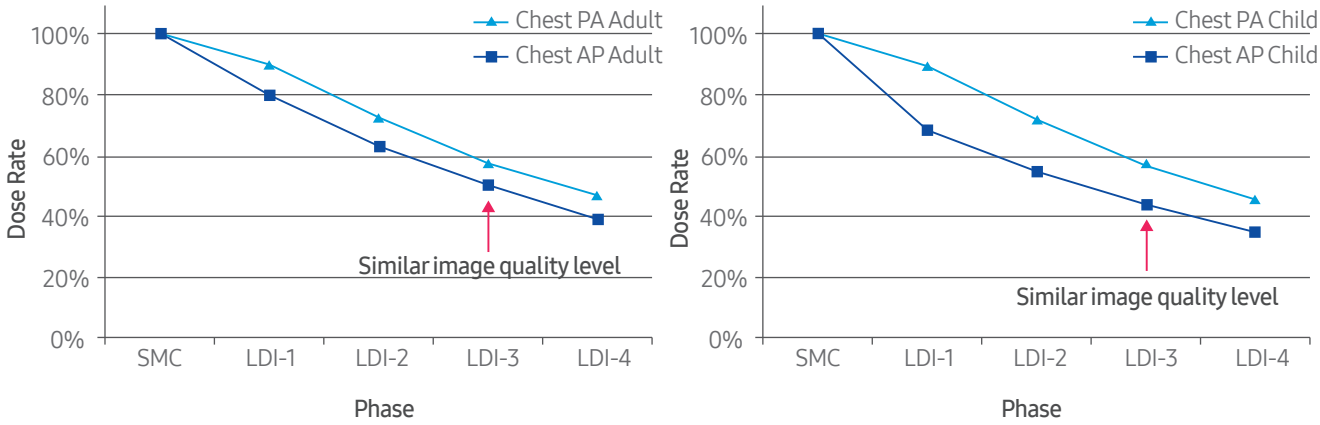

Figure 4. Dose reduction for same follow-up patients

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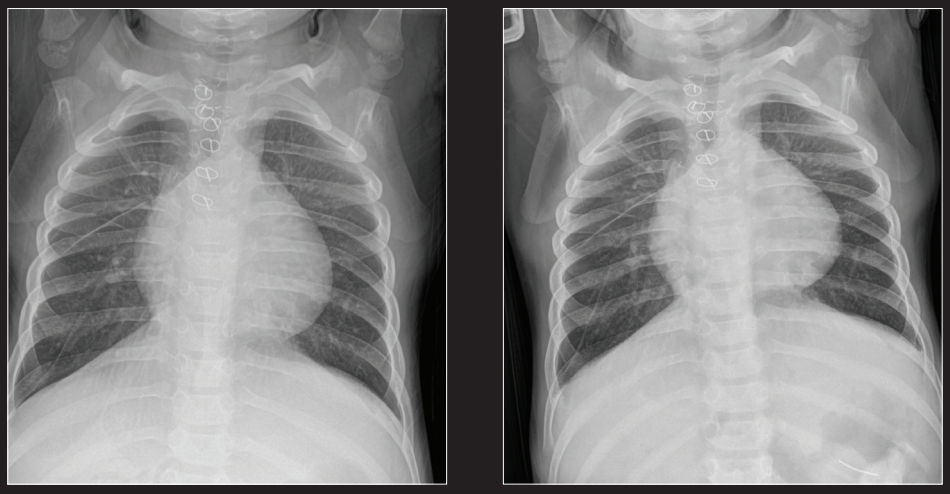
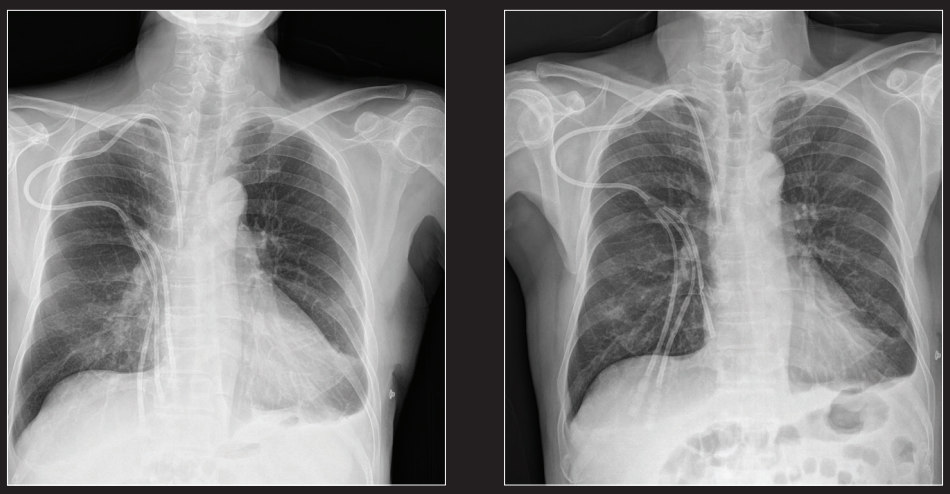
3. The comparison test for image quality
Figure 5 (a), (b) and Figure 6 (a), (b) show the images both for a normal dose and for a reduced dose for same follow-up patients. In spite of a reduced dose, the image quality can be maintained constantly.



(a) normal exposure and default post-processing (62kVp, 2.45mAs, 92.8 uGy)

(b) reduced dose and low-dose post-processing (Cu 0.1mm, 64kVp, 2.0mAs, 38.9 uGy)

Figure 5. Chest PA of Child



(a) normal exposure and default post-processing (117kVp, 0.94mAs, 40.1uGy)

(b) reduced dose and low-dose post-processing (Cu 0.1mm, 107kVp, 0.82mAs, 18.3uGy)

Figure 6. Chest PA of Adult

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Conclusion

SMC achieved about 32%~50% radiation dose reductions for chest protocol using Samsung x-ray system compared to the current exposure condition. According to Basic Safety Standards (BSS) No. 115[3] that recommends jointly at six international organizations including WHO and IAEA, an adult chest PA protocol can provide about 93% reduced dose compared to the recommended value of BSS no.115, about 91% compared to that of Germany, about 81% compared to that of U.K., and about 43% compared to the dose level used in SMC. Also, an child chest PA protocol can provide about 79% reduced dose compared to the guideline of EC(European Commission) for 5 years child, about 70% compared to that of U.K., and about 43% compared to the dose level used in SMC.

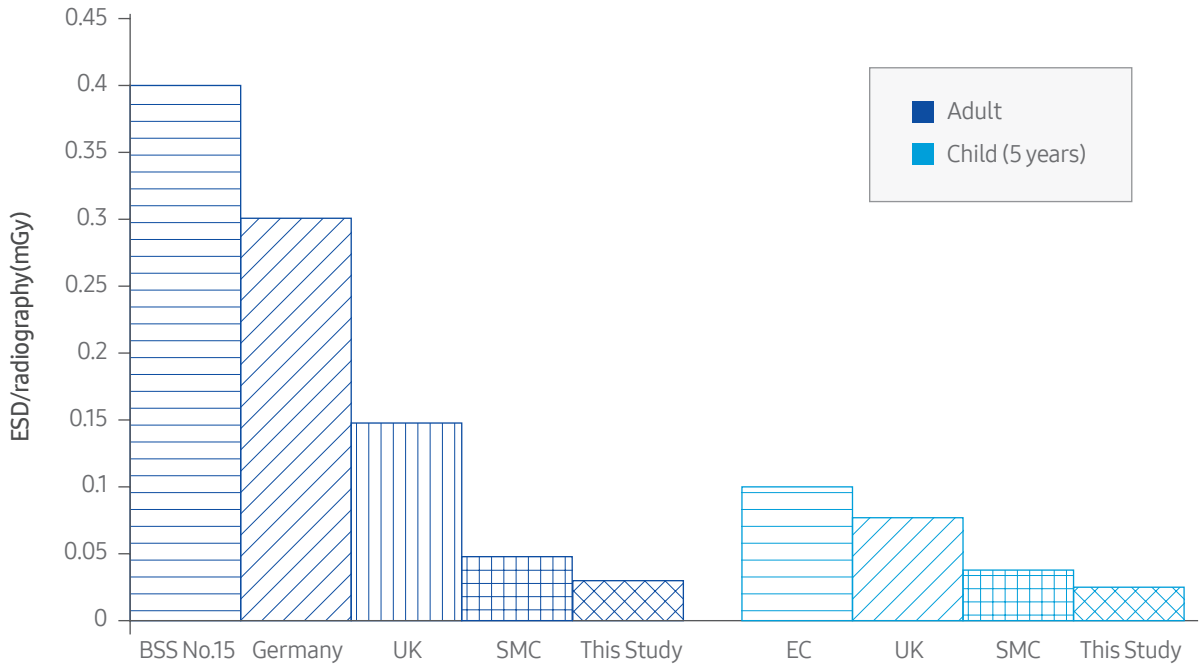

Figure 7. Optimized dose level for dose guideline of chest PA protocol

References

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2. D. R. Pina et al., Phantom development for radiographic image optimization of chest, skull and pelvis examination for nonstandard patient, Applied Radiation and Isotopes, 2009, 67, 61-69.

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4. European Commission. European Guidelines on Quality Criteria for Diagnostic Radiographic Images EUR 16260 EN, Luxembourg; 1996.

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