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# Long-Term Experience with CT Dose Monitoring: Implementation, Optimization and Outcome

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## ABSTRACT

**Purpose:** This presentation shares insights gained over 6 years of implementing a dose monitoring software for Computed Tomography (CT) exams across a large, multi-campus hospital. By sharing our experience, we aim to help other institutions in achieving a smoother and more efficient software implementation, ultimately enabling faster protocol optimization and patient dose reduction.
**Methods:** The initial phase of a dose monitoring system optimization involved proper configuration of all hardware and alert thresholds to ensure comprehensive exam monitoring. This included verifying that all imaging units transmitted the Radiation Dose Structured Report (RDSR) to the Picture Archiving Communication System (PACS) upon exam completion, and that all study descriptions were correctly mapped to their corresponding Study Common Name (SCN). Once the system configuration was completed, the monitoring phase began. All alerts were reviewed and analyzed for trends, allowing targeted efforts toward protocol optimization and/or staff training initiatives. Alert thresholds were initially based on published recommendations from recognized professional organizations and regulatory agencies, and subsequently, fined tuned to reflect site-specific conditions.
**Results:** Over the 6-year period, more than 60 protocols were optimized. Protocol modifications included adjustments on parameters such as the pitch, kVp, dose curve configuration, Computed Tomography Dose Index ($CTDI_{vol}$) phantom size as well as multiple manufacturer-specific dose modulation settings. The software also identified opportunities for staff training to reduce avoidable increase in patient dose related to patient positioning, over-ranging or other technical factors.
**Conclusions:** A dose monitoring software is an effective tool when properly configured and consistently utilized to identify areas requiring optimization. Since implementation, numerous protocols have been refined, and staff training was instituted resulting in patient dose reduction while maintaining optimal image quality.

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## INTRODUCTION

This presentation highlights key considerations for implementing and maintaining a CT dose monitoring system in a large, multi-campus hospital.

During implementation, monitoring rules were created at the SCN level to capture multiple protocols under a single rule. Protocol-specific rules can be used when dose thresholds differ significantly under the same SCN. Rules were applied at the series level, based on accreditation agencies or expert recommendations. When unavailable, institution's or dose registry's 75th percentile were used as a starting point.

The initial implementation may generate numerous alerts. At this stage, emphasis should be placed on identifying recurring trends rather than isolated events. Frequent alerts for the same examination across one or more scanners should prompt a protocol review.

As implementation progresses, alerts should decrease, allowing the software to support comparison of dose metrics across commonly used protocols. Protocols that do not exceed alert thresholds should still undergo periodic review to ensure radiation dose and image quality remain optimized.

When optimized protocols trigger alerts, technologist-dependent factors may be contributing. The dose monitoring software can identify opportunities for targeted education and workflow improvements to further reduce patient radiation exposure.

Overall, a dose monitoring system supports radiation dose optimization, protocol standardization, image quality improvement and identification of training needs.

## METHODS AND MATERIALS

After the threshold levels were established, series-level dose monitoring rules were created for each SCN used at our institution during the preceding 2 years, with separate rules for adult patients and each American College of Radiology (ACR)-defined pediatric age group[1]. For each SCN, two rules were built: one based on $CTDI_{vol}$ and one based on Dose Length Product (DLP).

Rules are reviewed at least annually to ensure threshold appropriateness and to confirm that all clinically used protocols remain covered.

When an increase in dose alerts for a specific rule is identified, a protocol review is initiated. Acquisition parameters are evaluated and, when feasible, compared with equivalent protocols on scanners that generate fewer alerts.

In collaboration with the manufacturer's applications specialists, protocols are standardized to achieve consistent image quality. Following implementation of protocol modifications, image quality is reviewed by a radiologist.

## RESULTS

Since implementation of the dose monitoring system, more than 60 protocols were modified. The parameters most frequently adjusted were the reference effective mAs, mA range, pitch, kVp and Noise Index (NI), accounting for approximately 62% of all documented parameter modifications (Chart 1). Other modifications included reconstruction and dose modulation settings as well as topogram parameters adjustments. Chart 2 demonstrates examples of $CTDI_{vol}$ reduction ranging from 21% to 72% following dose monitoring guided protocol optimization.

Dose monitoring also identified technologist-dependent factors that were addressed through targeted in-service education, including patient positioning errors (off-centering or body part tilt), excessive scan coverage (over-ranging), incorrect protocol selection, inadequate topogram coverage and inappropriate shielding use.

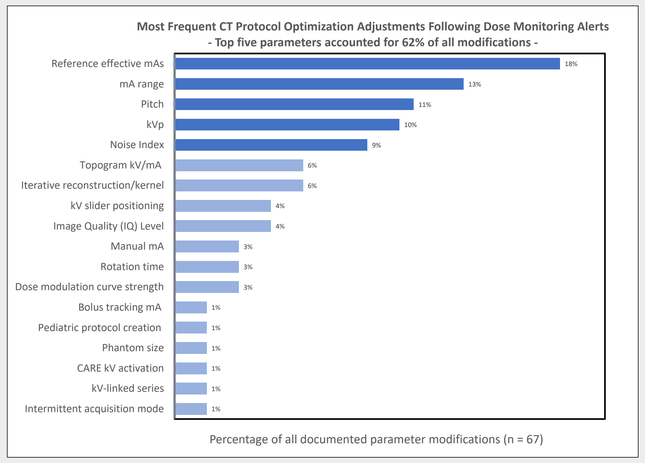


**Chart 1.** Distribution of protocol parameter modifications performed following dose monitoring alerts. Reference effective mAs, mA range, pitch, kVp and NI accounted for the majority of adjustments.

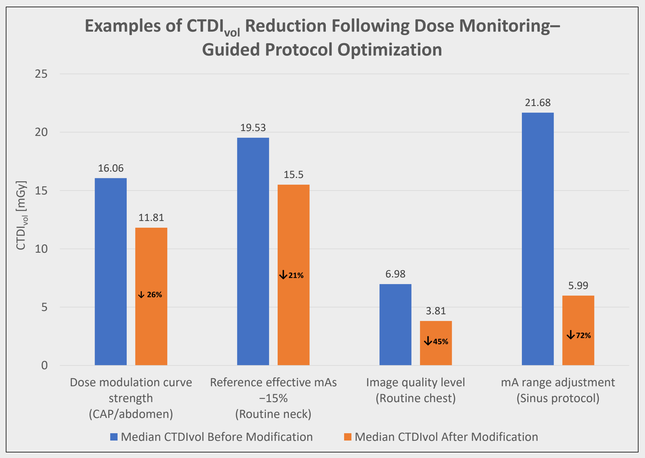


**Chart 2.** Examples of $CTDI_{vol}$ reduction following dose monitoring–guided protocol optimization. Modifications included adjustments to dose modulation settings, reference effective mAs, image quality level, and mA range.

## DISCUSSION

Older CT scanners may have reduced dose efficiency and may not achieve the same $CTDI_{vol}$ levels as newer systems while maintaining comparable image quality. However, substantial differences in estimated CTDIvol between scanners for similar examinations should prompt further investigation.

In a large multi campus healthcare system, protocol variability across scanners is expected due to differences in equipment, clinical requirements, and local optimization practices. Trend-based alert monitoring can identify areas requiring attention, while analytics reports provide more detailed comparisons between scanners and protocols. High-volume protocols should be prioritized for review to maximize optimization impact.

Configuring alert rules at the series level rather than the study level can reduce false-positive alerts. Study level monitoring may generate alerts for a large proportion of combined examinations, limiting the usefulness of the system. However, series-level monitoring may not capture unnecessary repeated series.

Patient positioning errors and larger than average patient may contribute to increase dose alerts, because of their effects on automatic exposure control. Initial alert thresholds should be established conservatively to identify optimization opportunities. As protocols are reviewed and optimized over time, thresholds can be adjusted to reduce unnecessary alerts associated with patient size variations and positioning limitations.

## CONCLUSIONS

CT dose monitoring is an on-going process that requires regular oversight and continuous optimization. Establishing alert rules at the SCN level allows efficient initial implementation and enable monitoring of newly added protocol that may not have been identified during set up. However, because protocols grouped under the same SCN may produce different radiation outputs, future optimization should focus on developing protocol-specific rules.

Determining appropriate thresholds for less frequently performed examinations can be challenging. Over time, thresholds must be reassessed to accommodate advances in CT technology and ensure that protocol modifications and additions are appropriately monitored. Collaboration with radiologists and lead technologists is essential to identify dose optimization opportunities for both new and legacy protocols.

## REFERENCES

1. Kaplan, Kalpana M, et al. "U.S. Diagnostic Reference Levels and Achievable Doses for 10 Pediatric CT Examinations." *Radiology*, 26 Jan. 2022.

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