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IMAGING

QUALITY IMPROVEMENT PROJECTS

Radiation Dose Optimization in a Multicenter CCTA Program

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ABSTRACT

BACKGROUND Excessive radiation exposure from coronary computed tomography angiography (CCTA) increases lifetime malignancy risk. Internal review within a 5-hospital health system revealed median system-wide doses above best-practice targets, with high intercampus variability.

PROJECT RATIONALE Dose optimization is a modifiable patient safety measure supported by national guidelines, with evidence that reduction can be achieved without loss of diagnostic quality.

PROJECT SUMMARY Implementation of standardized, evidence-based CCTA protocols across the health system reduced the median radiation dose from 6.2 millisievert (mSv) to 4.8 mSv (23% reduction) while improving diagnostic acceptance from 90.5% to 92.7% ($P = 0.019$). Improvements were consistent across campuses despite equipment variability and were sustained through ongoing monitoring, staff education, and leadership engagement. This initiative provides a scalable model for achieving ≤4 mSv best-practice targets in multicenter cardiovascular imaging programs.

TAKE-HOME MESSAGES Tracking radiation doses is imperative. Standardized, evidence-based protocols can achieve sustainable CCTA radiation dose reduction across diverse campuses without compromising diagnostic quality. (JACC Case Rep. 2025;30:105612) © 2025 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Coronary computed tomography angiography (CCTA) provides high diagnostic accuracy for coronary artery disease but contributes to cumulative radiation exposure, which carries a measurable malignancy risk. A recent analysis in the *Journal of the American Medical Association* of over 121,000 computed tomography (CT) examinations projected that, if current usage and dose levels persist, CT imaging could account for approximately 5% of new cancer cases in the United States annually. Although CCTA represents only about 1% of the projected cases, its radiation exposure is modifiable through optimization strategies.[1]

Evidence from multicenter studies demonstrates that substantial radiation dose reduction is achievable without compromising diagnostic quality. The PROTECTION VI trial achieved a median dose of 2.7 millisievert (mSv) across 61 centers with no increase

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ABBREVIATIONS AND ACRONYMS

BMI = body mass index

CCTA = coronary computed tomography angiography

CT = computed tomography

FFRct = fractional flow reserve derived from computed tomography

in nondiagnostic scans,[2] and a low-tube-potential subanalysis demonstrated median doses as low as 1.4 to 2.2 mSv with stable diagnostic rates and improved image quality.[3] The SCOT-HEART trial reported a median dose of 4.1 mSv alongside increased diagnostic certainty.[4]

Baseline audits conducted within a 5-hospital health system from February to July 2024 revealed a median system-wide CCTA dose of 6.2 mSv, with significant intercampus variability ranging from 2.9 to 12.5 mSv. These findings exceeded the performance demonstrated in multicenter trials and highlighted the need for protocol optimization and standardization. Guided by this evidence, a pragmatic best-practice goal of a median CCTA dose of ≤4 mSv was set. This target is supported by the 2021 American Heart Association/American College of Cardiology chest pain guideline[5] and the Society of Cardiovascular Computed Tomography expert consensus,[6] which—although not prescribing a fixed numeric threshold—explicitly endorse the ALARA ("as low as reasonably achievable") principle,[7] protocol standardization, and ongoing dose monitoring as essential quality metrics for CCTA programs. These findings formed the foundation for a system-wide quality improvement initiative to standardize protocols and reduce radiation exposure while maintaining diagnostic quality.

TAKE-HOME MESSAGES

- This project demonstrates that coronary computed tomography angiography radiation dose can be reduced by more than 20% without compromising diagnostic quality through the implementation of standardized, evidence-based protocols.
- Consistent improvements can be achieved across multiple campuses, even when equipment differs, provided that leadership support, staff engagement, and continuous monitoring are in place.

PROJECT RATIONALE

Radiation dose reduction is a measurable, evidence-supported patient safety goal. Large-scale population studies have shown that cumulative radiation from medical imaging contributes to overall cancer incidence, with CT estimated to account for up to approximately 5% of new cases annually in the United States if current dose levels persist.[1] While the individual risk from a single CCTA is low, the rapid growth in cardiac CT use, combined with the potential for repeat imaging, amplifies the importance of minimizing exposure wherever possible. Beyond patient safety, dose optimization is an important quality metric in cardiovascular imaging, supported by professional society guidelines that advocate for the ALARA principle without compromising diagnostic image quality.[5-7]

PROJECT DESCRIPTION

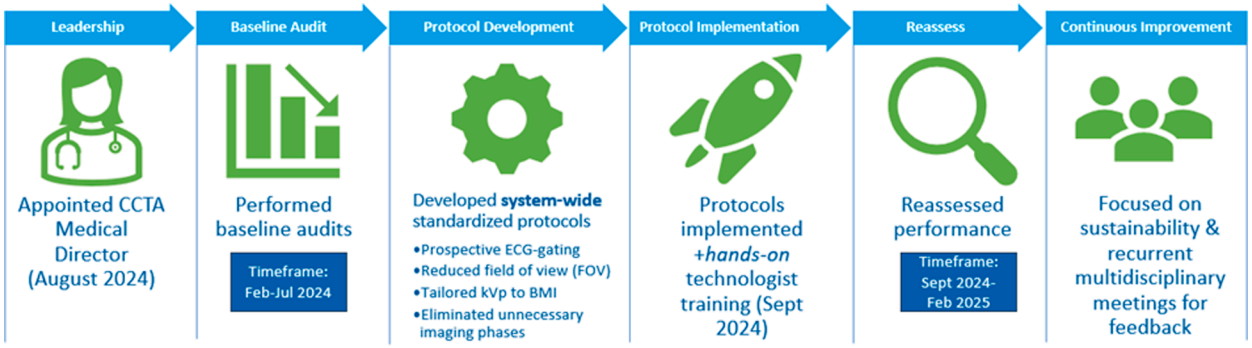
A multidisciplinary team was convened to develop and implement a standardized CCTA protocol across all campuses in the health system. Leadership appointed a dedicated CCTA medical director to oversee the project and ensure alignment across sites. Baseline radiation dose data were collected between February and July 2024, revealing significant variability in exposure levels. Based on these findings, the team designed standardized protocols emphasizing prospective electrocardiogram gating, reduced field of view, body mass index (BMI)-tailored tube voltage (kilovoltage peak [kVp]), and the elimination of redundant imaging phases. For the single-source scanners, prospective scanning between 60% to 80% of the cardiac cycle was implemented, using 100 kVp for patients with BMI <30 and 120 kVp for BMI ≥30. For the dual-source scanners, systolic imaging between 250 to 450 milliseconds was implemented, with 100 kVp for patients with BMI <30 and 120 kVp for BMI ≥30.

In September 2024, these protocols were implemented system-wide, accompanied by hands-on training sessions for CT technologists to promote adoption and address site-specific challenges. After implementation, radiation dose data were reassessed from September 2024 through February 2025, and multidisciplinary meetings were held regularly to review performance metrics, gather feedback, and identify further improvement opportunities (**Figure 1**).

PROJECT DELIVERABLES

The project sought to align system-wide CCTA radiation doses with the ≤4 mSv best-practice goal derived from multicenter trial performance[2-4] and consistent with the principles outlined in professional society guidelines.[5-7] The project also aimed to reduce variability in radiation exposure between the 5 campuses (designated here as CCH, CP, GC, HP, and LM), ensuring consistent protocol adherence regardless of scanner type or site. Maintaining or improving diagnostic image quality, as measured by an independent outside source (HeartFlow CCTA fractional flow reserve derived from CT [FFRct] diagnostic acceptance rate), was an equally important deliverable.[8]

FIGURE 1 **Standardized CCTA Radiation Dose Optimization Workflow**



This figure illustrates the stepwise process of developing and implementing a system-wide coronary computed tomography angiography (CCTA) radiation dose reduction initiative. Leadership appointed a CCTA medical director (August 2024), baseline audits were conducted (February-July 2024), and system-wide standardized protocols were developed emphasizing prospective electrocardiogram (ECG)-gating, body mass index (BMI)-tailored tube voltage (kVp), reduced field of view (FOV), and elimination of unnecessary imaging phases. Protocols were implemented in September 2024 alongside hands-on technologist training. Performance was reassessed from September 2024 through February 2025, followed by continuous improvement efforts through sustainability planning and multidisciplinary feedback. kVp = kilovoltage peak.

PROJECT OUTCOME, IMPACT AND FUTURE DIRECTIONS

Implementation of the standardized protocols resulted in a reduction of the median system-wide radiation dose from 6.2 to 4.8 mSv, representing a 23% decrease (**Figure 2**). Dose consistency was achieved across all 5 campuses despite differences in scanner models and baseline practices. Diagnostic quality, measured by the FFRct acceptance rate, improved overall from 90.5% to 92.7%, reflecting a 2.2% increase (95% confidence interval: 0.4%-4.0%; $P = 0.019$). The largest improvement occurred at the LM campus, which increased by 21.9% (95% confidence interval: 14.0%-29.8%; $P < 0.001$), followed by a steady gain at the CP campus of 2.1% (95% confidence interval: 0.4%-3.9%; $P = 0.018$). The CCH and GC campuses demonstrated modest, non-statistically significant increases, and the HP campus experienced a small, non-statistically significant decrease but remained above 90% and within confidence limits (**Figure 3**).

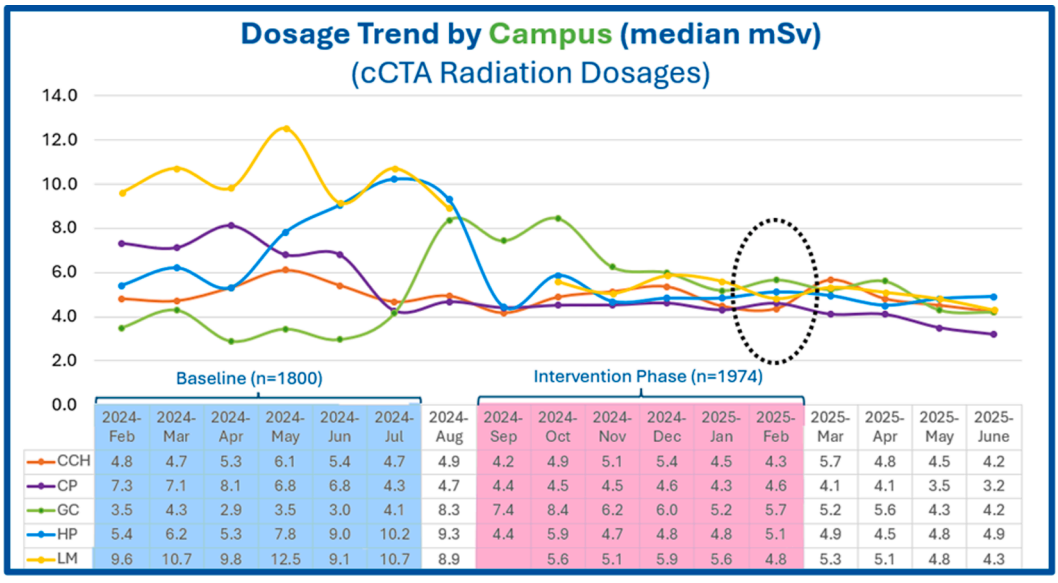
The impact of this initiative demonstrates that protocol standardization can be successfully scaled across diverse facilities without compromising image quality. Looking ahead, the health system plans to enhance protocol performance by acquiring additional dual-source CT scanners, introducing systolic phase imaging protocols to reduce the need for heart rate control medications, and appointing site-specific quality assurance technologists to maintain adherence. Continuous monitoring of radiation doses and ongoing staff education will remain central to sustaining these improvements over the long term.

DISCUSSION

This quality improvement project demonstrates that targeted, evidence-based interventions—when supported by leadership and multidisciplinary collaboration—can significantly reduce CCTA radiation doses across a multicenter health system. Dose reduction was accompanied by maintained, and in some cases improved, diagnostic acceptance rates, underscoring the feasibility of achieving safety gains without compromising quality. Although this was a cardiology-led quality improvement initiative, it was implemented through a multidisciplinary team that included radiologists, advanced practice clinicians, radiology technologists, and nurses. The proposed protocols were developed by the cardiology imaging team and subsequently reviewed and endorsed by radiology leadership without opposition. The protocol changes were transparent to patients and did not alter their overall experience.

A critical element of the quality improvement initiative was systematic tracking of radiation doses for CCTA. Such monitoring is imperative for a CCTA program committed to quality and patient safety. Historically, radiation exposure monitoring is not consistent in all programs, limiting insight into

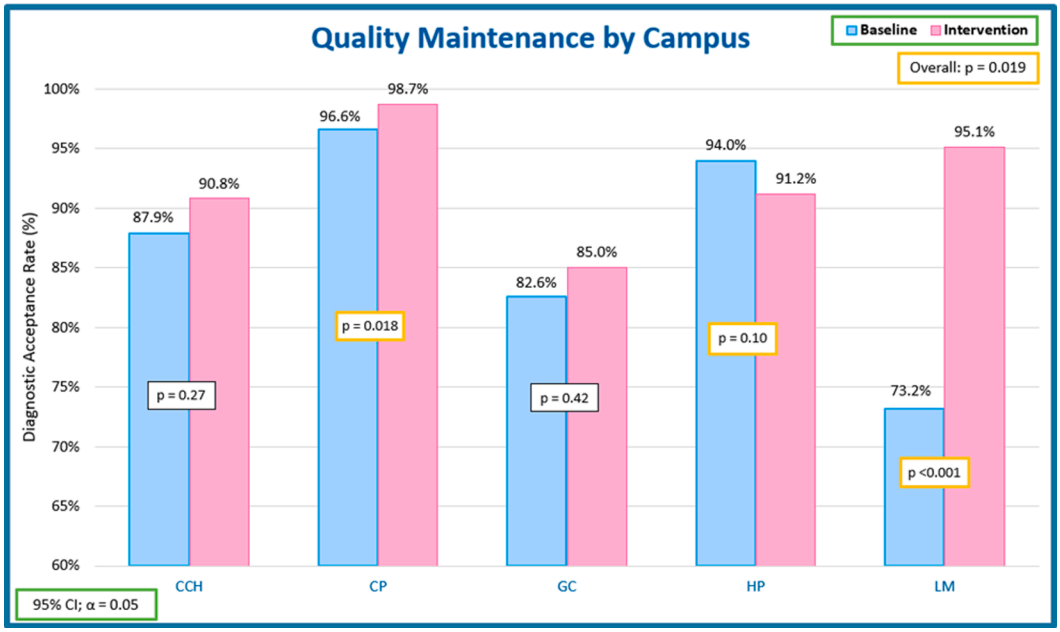
FIGURE 2 **Dosage Trend by Campus (Median mSv)**



	2024-Feb	2024-Mar	2024-Apr	2024-May	2024-Jun	2024-Jul	2024-Aug	2024-Sep	2024-Oct	2024-Nov	2024-Dec	2025-Jan	2025-Feb	2025-Mar	2025-Apr	2025-May	2025-June
CCH	4.8	4.7	5.3	6.1	5.4	4.7	4.9	4.2	4.9	5.1	5.4	4.5	4.3	5.7	4.8	4.5	4.2
CP	7.3	7.1	8.1	6.8	6.8	4.3	4.7	4.4	4.5	4.5	4.6	4.3	4.6	4.1	4.1	3.5	3.2
GC	3.5	4.3	2.9	3.5	3.0	4.1	8.3	7.4	8.4	6.2	6.0	5.2	5.7	5.2	5.6	4.3	4.2
HP	5.4	6.2	5.3	7.8	9.0	10.2	9.3	4.4	5.9	4.7	4.8	4.8	5.1	4.9	4.5	4.8	4.9
LM	9.6	10.7	9.8	12.5	9.1	10.7	8.9		5.6	5.1	5.9	5.6	4.8	5.3	5.1	4.8	4.3

This figure illustrates median coronary computed tomography angiography (cCTA) radiation doses (mSv) across 5 campuses (CCH, CP, GC, HP, and LM) from February 2024 to June 2025. The baseline phase (n = 1,800; shaded blue) showed substantial intercampus variability and elevated median doses. After system-wide protocol implementation (n = 1,974; shaded pink), radiation doses converged and decreased, with improved consistency across sites. The dotted black circle highlights the stabilization period at the end of the intervention phase. These results demonstrate that standardized protocols, continuous tracking, and multidisciplinary oversight enabled sustainable system-wide dose reduction while maintaining diagnostic performance. mSv = millisievert.

FIGURE 3 **Quality Maintenance by Campus**



This figure presents diagnostic acceptance rates across the 5 campuses (CCH, CP, GC, HP, and LM) during baseline and intervention phases. Acceptance rates were preserved or improved after standardized protocol implementation, with significant improvements observed at select sites ($P = 0.018$ at CP, $P < 0.001$ at LM; overall $P = 0.019$). These findings confirm that radiation dose reduction was achieved without compromising diagnostic image quality. CI = confidence interval.

actual performance.[9] When the cardiology program assumed ownership of dose monitoring, elevated and highly variable baseline doses were identified, providing a clear impetus for change and improvement. Establishing routine dose tracking not only confirmed this performance gap but also created the infrastructure for continuous quality improvement. The resulting transparency fostered engagement from technologists, cardiologists, radiologists and administrators, and ensured that subsequent interventions could be tailored to address site-specific challenges.

This approach aligns with published literature, including the PROTECTION VI[2,3] and SCOT-HEART[4] trials, which demonstrated that meaningful dose reduction is possible without loss of diagnostic yield. By tailoring protocols to patient BMI, prioritizing prospective gating, and streamlining imaging phases, we were able to achieve results in real-world practice that were comparable to national benchmarks.

Scalability is supported by the success across sites with differing scanner types and baseline practices, indicating that similar health systems could reproduce these results by combining standardized protocols with structured implementation, training, and continuous monitoring.

Despite not achieving the target goal of ≤4mSv, significant improvement was achieved in the intervention phase with further work planned towards future improvement.

CONCLUSIONS

System-wide CCTA radiation dose optimization is achievable through standardized protocols, leadership engagement, and multidisciplinary education. Sustained improvement requires continuous monitoring and adaptation to evolving technology.

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