Quantitative Assessment of Diagnostic Image Quality Adequacy In Neck CT: Evidence for Physics-Informed Protocol Redesign

Hayley Cash, MS[1], Rafael Carballeira[2], Marthony Robins, PhD[2,3]
[1]Medical University of South Carolina, Charleston
[2]Dartmouth College, Hanover, NH
[3]Dartmouth Hitchcock Medical Center, Lebanon, NH

2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

ABSTRACT

Purpose: Neck CT protocols often present challenges for objective lesion detectability tasks. We systematically assessed lesion detectability in clinical scans to identify quality gaps and dose utilization inefficiencies.
Methods: We analyzed 42 clinical neck CT examinations using a custom task-based automated image quality (IQ) assessment tool (AnatomIQ). We drew circular ROIs around lesions with the tool automatically extracting Hounsfield Unit (HU) values from the ROI center and sampled multiple background candidate regions with similar HU values in the surrounding area. Evaluation metrics included CNR, detectability index (d'=CNR×√Area), Weber contrast, and the dose-normalized figure of merit (CNR2 /dose). Lesions were classified using the Rose criterionbased threshold for IQ-adequacy (i.e., adequate: CNR ≥1.0). CTDIvol was used to estimate Sizespecific dose estimates (SSDE).
Results: Systematic assessment demonstrated 45% (19/42) inadequacy (CNR0.80), while d' strongly correlated with both contrast (r=0.60, p0.60), with IQ-inadequate cases receiving a higher mean dose (10.3±4.6 mGy) than IQ-adequate cases (9.7±3.1 mGy, p=0.90). Notably, 78% of IQ-inadequate cases occurred at doses below the AD. However, IQ-inadequacy was also observed in high dose cases up to 19.76 mGy (CNR=0.13) demonstrating that elevated doses alone might not compensate for insufficient lesion contrast.
Conclusion: Automated quantitative assessment identified lesion detectability deficiencies in clinical neck CT independent of radiation dose. These findings emphasize the need for contrast and reconstruction driven protocol redesign guided by task-based IQ metrics rather than traditional dose benchmarks alone.

CONTACT

Hayley Cash
Medical University of South Carolina
cashhay@musc.edu

Methods

Study	Metrics
• 42 clinical neck CT exams, contrast-enhanced	$CNR = \frac{\mid \mu_{lesion} - \mu_{bkg} \mid}{\sigma_{bkg}}$
• Assessed with **AnatomIQ** (in-house, patent pending)	$d' = CNR \times \sqrt{A_{lesion}}$
• Circular ROI at lesion center; automated background sampling at matched HU	$C_W = \frac{\mu_{lesion} - \mu_{bkg}}{\mu_{bkg}}$
• SSDE per AAPM Report 204 (n=14 with reported SSDE)	$FOM = \frac{CNR^2}{SSDE}$
• Adequacy: Rose criterion, CNR ≥ 1.0	$SSDE = f_{size} \times CTDI_{vol}$
• Reference: ACR AD (15 mGy), DRL (19 mGy)	
• Stats: Pearson r, linear regression, t-test, α = 0.05	

Discussion

Inadequacy is widespread. 45% of clinical neck CTs failed the Rose-criterion threshold for lesion detectability across a 4-fold dose range, indicating current protocols are not reliably diagnostic for lesion tasks.
The problem isn't dose. IQ-inadequate cases received slightly *higher* mean SSDE than adequate cases (10.3 ± 4.6 vs 9.7 ± 3.1 mGy, p = 0.90), with no dose–detectability correlation (R^2 = 0.030). One case at 19.76 mGy — above the DRL — yielded CNR of only 0.13.
The problem is contrast. All inadequate cases had ΔHU < 20, and CNR correlated near-perfectly with lesion contrast (r = 0.99). 78% of inadequate cases occurred *below* the AD — low conspicuity, not low dose, is the failure mode.
CNR alone is insufficient. CNR showed zero correlation with lesion area (r = 0.03), while d′ correlated with both area (r = 0.77) and contrast (r = 0.60), capturing geometric factors CNR misses.
Clinical implications. Dose benchmarks (AD, DRL) regulate exposure but not task adequacy. Protocol redesign should target contrast delivery, reconstruction, and energy parameters rather than dose alone. The high-dose / low-FOM "waste zone" (Fig. 1D) is the most actionable target.
Limitations. Modest sample (n = 42; SSDE for 14), single institution, single reader. Prospective multi-reader validation planned.

RESULTS

KEY RESULTS

45% (19/42) of clinical neck CTs failed the Rose-criterion threshold (CNR < 1.0)
No dose–detectability correlation (R^2 = 0.030, p > 0.60); inadequate cases received slightly *higher* mean dose than adequate (10.3 ± 4.6 vs 9.7 ± 3.1 mGy)
100% of inadequate cases had lesion contrast ΔHU < 20; **78%** occurred *below* the ACR AD
Extreme case: 19.76 mGy (above DRL) → CNR = 0.13
CNR correlates with contrast (r = 0.99) but **not** lesion area (r = 0.03); d′ captures both (r = 0.60, r = 0.77)

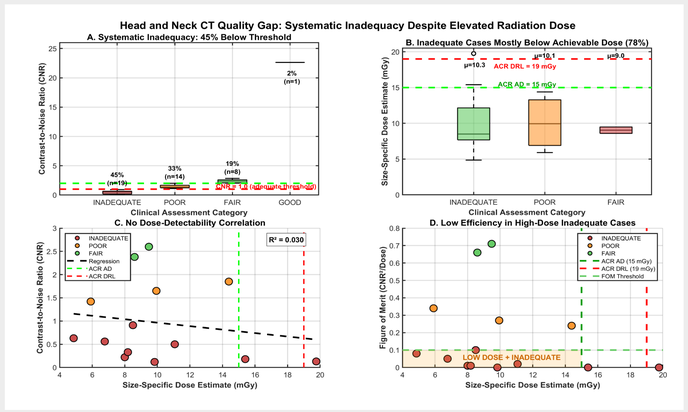

Figure 1A-D: Systematic quality gap analysis in clinical neck CT (n=42). (A) CNR distribution shows 45% inadequacy. (B) IQ-Inadequate cases at elevated dose (μ=10.3±4.6 mGy vs 9.7±3.1 mGy adequate). (C) No dose-detectability correlation (R^2=0.030). (D) Low dose efficiency (FOM) in high-dose IQ-inadequate cases ("waste zone").

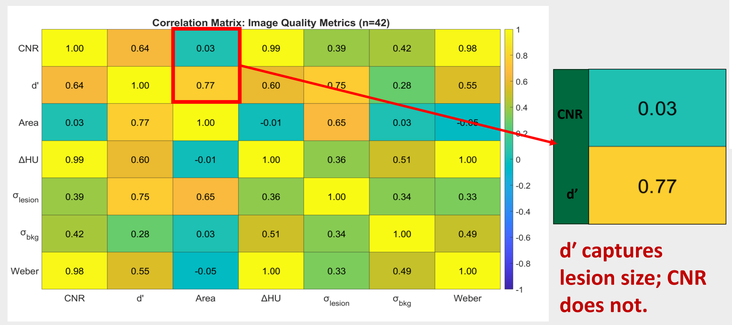

Figure 2. Pearson correlation heatmap of image quality metrics (n=42). CNR correlates near-perfectly with lesion contrast (ΔHU: r=0.99) and Weber contrast (r=0.98) but not with lesion area (r=0.03). Detectability index (d') correlates with both area (r=0.77) and contrast (r=0.60), capturing geometric factors CNR misses. Color scale: −1 (blue) to +1 (yellow).

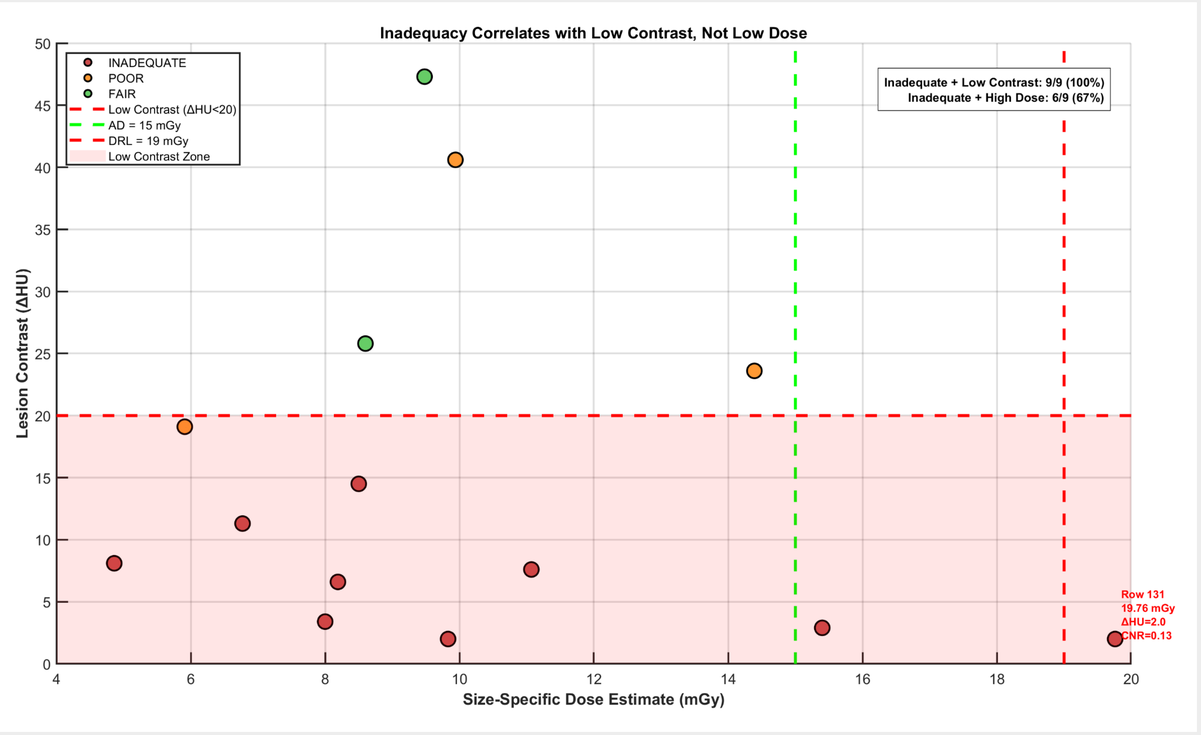

Figure 3. Lesion contrast (ΔHU) vs. SSDE for all assessed cases, stratified by IQ adequacy. **100% of IQ-inadequate cases (red zone) fell below ΔHU = 20**, while 67% occurred at doses above 8 mGy — confirming that low contrast, not low dose, drives detectability failure. The extreme case at **19.76 mGy with CNR = 0.13** (above the ACR DRL yet non-diagnostic) demonstrates that dose escalation cannot rescue insufficient lesion contrast. Vertical and horizontal reference lines mark the contrast and dose thresholds, respectively.

Conclusions

Automated quantitative assessment revealed that **45% of clinical neck CT lesions fall below the Rose-criterion detectability threshold**, with inadequacy driven by **low lesion contrast rather than low dose**. Dose escalation does not compensate for insufficient contrast — cases above the DRL still failed detectability. These findings support **physics-informed, task-based protocol redesign** focused on contrast optimization and reconstruction strategy, replacing dose benchmarks as the sole quality metric.