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abstract

A Novel Evaluation Formula for Plan Quality in Conventional Fractionated and Stereotactic Radiotherapy: Nabaa Efficiency Index (NEI)

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abstract

A Novel Evaluation Formula for Plan Quality in Conventional Fractionated and Stereotactic Radiotherapy: Nabaa Efficiency Index (NEI)

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Introduction: Evaluation of radiotherapy plan quality remains challenging across stereotactic radiosurgery (SRS) and fractionated radiotherapy. Existing indices, including the Paddick efficiency index, mainly quantify dose concentration and are optimized for single-fraction stereotactic delivery, with limited sensitivity to prescription-level conformity, dose balance, and fractionation effects. The aim was to introduce and validate the Nabaa Efficiency Index (NEI) as a unified geometric–dosimetric framework for plan-quality evaluation across stereotactic and fractionated radiotherapy modalities.

Methodology: The Nabaa Efficiency Index integrates the mean target dose with spatial conformity using prescription isodose volumes. The mean dose to the target volume (TV) was calculated as the integral of dose over the target volume divided by the target volume. Conformity was defined as the ratio of the target volume receiving the prescription dose to the total target volume. Two NEI variants were derived. The NEI at the 50% prescription isodose (NEI50) was defined as the mean target dose multiplied by the target volume and divided by the 50% prescription isodose volume, emphasizing dose compactness and fall-off sensitivity. The NEI at the 90% prescription isodose (NEI90) combined the conformity index at 90% with the ratio of mean target dose to the mean dose within the 90% prescription isodose volume, emphasizing prescription-level conformity and energetic efficiency. One hundred stereotactic treatment plans (50 Gamma Knife SRS and 50 SRS-VMAT) were retrospectively analyzed. Performance was benchmarked against the Paddick efficiency index. Clinical optimality was defined as PCI90 ≥ 0.70. Discrimination was evaluated using ROC analysis with bootstrap confidence intervals.

Results: NEI90 demonstrated superior discrimination compared with the Paddick efficiency index, particularly in SRS - VMAT (Δ AUC = 0.40, $p<0.001$), achieving sensitivity and specificity greater

than 0.93. In Gamma Knife SRS, NEI90 also showed strong discrimination (AUC = 0.902). NEI50 provided complementary sensitivity to intermediate-dose spills and peripheral dose control not captured by existing indices.

Conclusion: The Nabaa Efficiency Index provides a mathematically grounded and modality-independent framework for radiotherapy plan evaluation. NEI90 enables superior identification of clinically optimal plans, while NEI50 enhances assessment of dose balance and fall-off. Together, these indices extend plan-quality evaluation beyond current standards and support optimized decision-making in modern radiotherapy.

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