Imaging-Based Standardization of Non-Perfused Volume (NPV) in HIFU: A T2-Weighted and T1 Contrast-Enhanced MRI Framework

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BACKGROUND

- NPV is the most widely used imaging biomarker in HIFU treatment assessment.
- Current literature lacks a standardized imaging definition of the NPV denominator and numerator.
- This ambiguity may compromise NPV reproducibility and cross-study comparison.

Objective

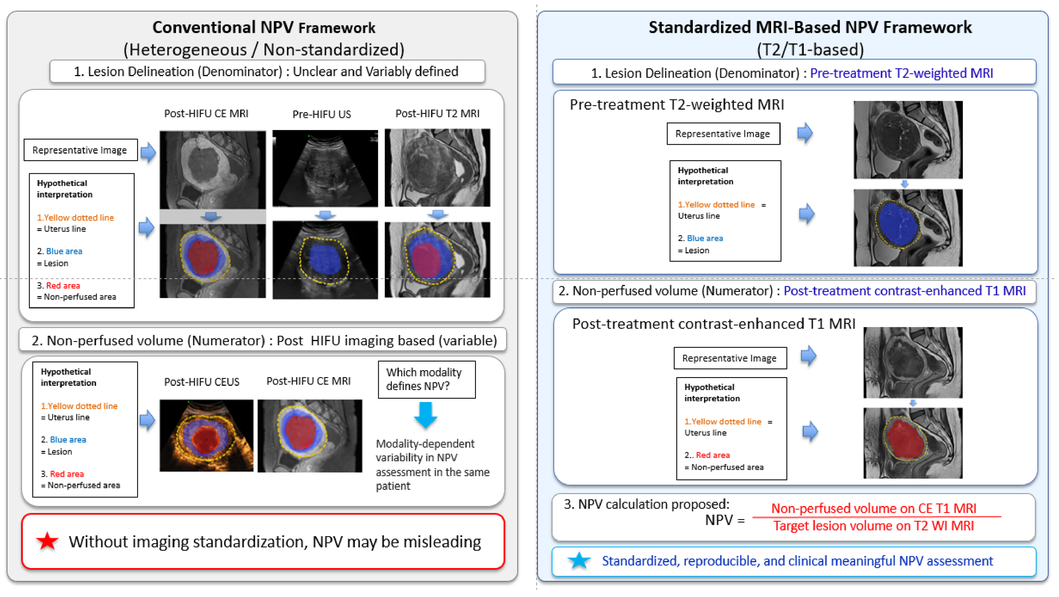
To propose an MRI-based framework for standardized NPV assessment using pre-treatment T2-weighted MRI and immediate post-treatment contrast-enhanced T1-weighted MRI.

METHODS

- Denominator: **Pre-treatment T2-weighted MRI**
- Numerator: **Immediate post-treatment CE-T1 MRI**
- Evaluated in:

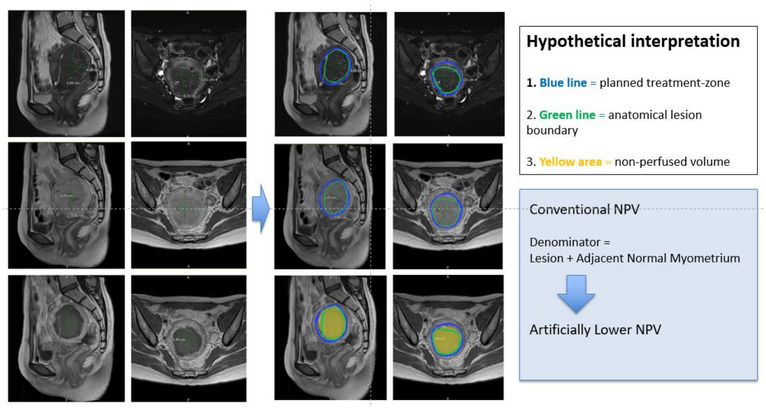
1. **Focal adenomyosis**
2. **Diffuse adenomyosis**
3. **Multiple fibroids**

Fig 1. Conventional NPV assessment versus the proposed standardized MRI-based NPV framework.



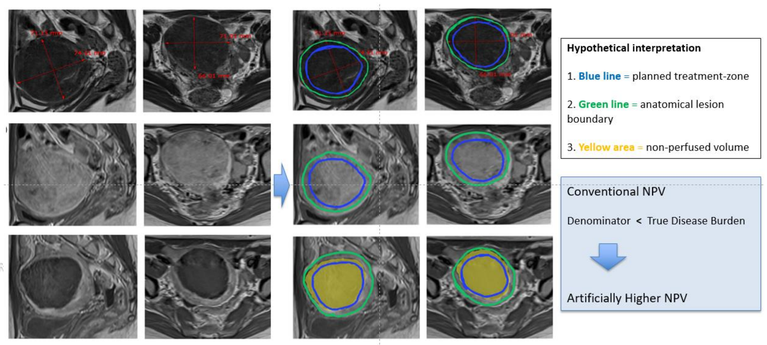
Conventional NPV assessment varies according to imaging modality and lesion definition.
The proposed T2WI/CE-T1WI framework standardizes the anatomical denominator and functional numerator of NPV.

Fig 2. Focal adenomyosis: Risk of NPV Underestimation



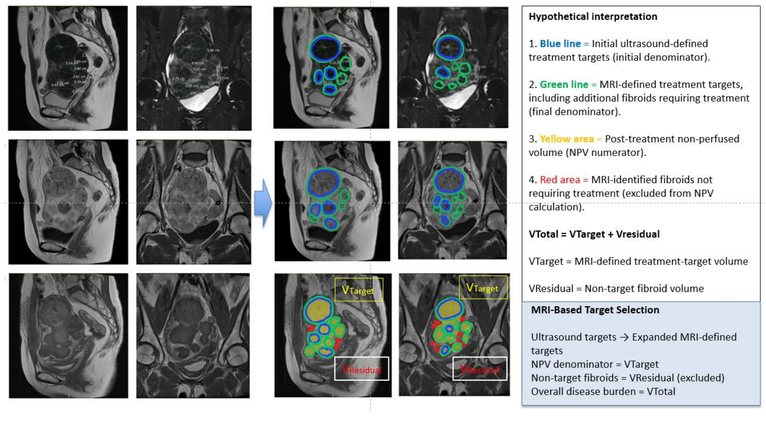
In focal adenomyosis, without a clearly defined pre-treatment anatomical lesion boundary, post-treatment contrast-enhanced MRI alone may lead to overestimation of lesion volume by including adjacent normal myometrium in the denominator, thereby underestimating the NPV ratio. The proposed framework uses pre-treatment T2-weighted MRI to define and preserve the anatomical lesion boundary.

Fig 3. Diffuse adenomyosis : Risk of NPV Overestimation.



Without prior delineation of the anatomical disease boundary on pre-treatment T2-weighted MRI, peripheral residual disease may be excluded from the denominator, artificially increasing the calculated NPV. The proposed framework preserves the full anatomical disease burden and aims to reduce denominator-related measurement bias.

Fig 4. MRI-Based Expansion of Treatment Targets and Differentiation of Residual Non-Target Fibroids



Ultrasound-based assessment may overlook clinically significant fibroids requiring treatment. Comprehensive pre-treatment T2-weighted MRI enables expansion of the treatment-target denominator to include these additional lesions, while fibroids not requiring treatment are classified separately as residual non-target disease. The MRI-defined target volume (VTarget) serves as the NPV denominator, whereas residual non-target volume (VResidual) is excluded. Overall multifibroid disease burden is represented by VTotal = VTarget + VResidual.

MAIN TAKEAWAY

MRI-Based Standardized NPV

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Denominator
T2WI Anatomical Volume

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Numerator
CE-T1WI Non-Perfused Volume

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Consistent NPV Calculation

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Standardized Clinical Assessment

CONCLUSIONS

- Pre-treatment T2-weighted MRI provides a consistent anatomical reference for NPV denominator definition.
- Immediate post-treatment contrast-enhanced T1-weighted MRI enables delineation of non-perfused tissue for the numerator.
- The proposed framework may improve NPV measurement consistency and clinical interpretability; further validation is needed to establish its accuracy and reproducibility.

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